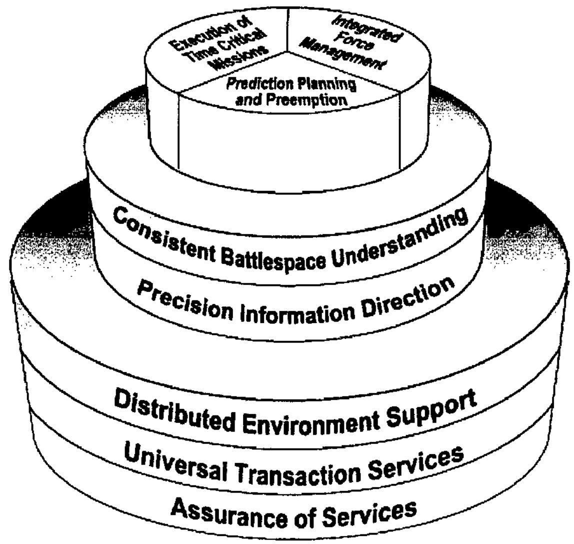

Advanced Battlespace Information System (ABIS)

Task Force Report

Volume IV

Sensor-to-Shooter Working Group Results

Director of Command, Control,
Communications, and Computers
(Joint Staff)

Director, Defense Research
and Engineering
(OSD)

May 1996

Advanced Battlespace Information System (ABIS)

Task Force Report
Volume IV

Sensor-to-Shooter Working Group Results

May 1996

Co-Chairmen:
Dr. B. Deal, OUSD (A&T)
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Preface

This is Volume IV of the final report of the Advanced Battlespace Information System (ABIS) Task Force. The entire final report is organized into six separately bound volumes:

I. Executive Summary

II. Major Results

III. Battle Management Working Group Report

IV. Sensor-to-Shooter Working Group Report

V. Grid Capabilities Working Group Report

VI. Supporting Annexes

This volume is the full report of the Sensor-to-Shooter Working Group. It contains an executive summary of the major findings and conclusions and a detailed discussion of the specific areas that were considered by the working group.

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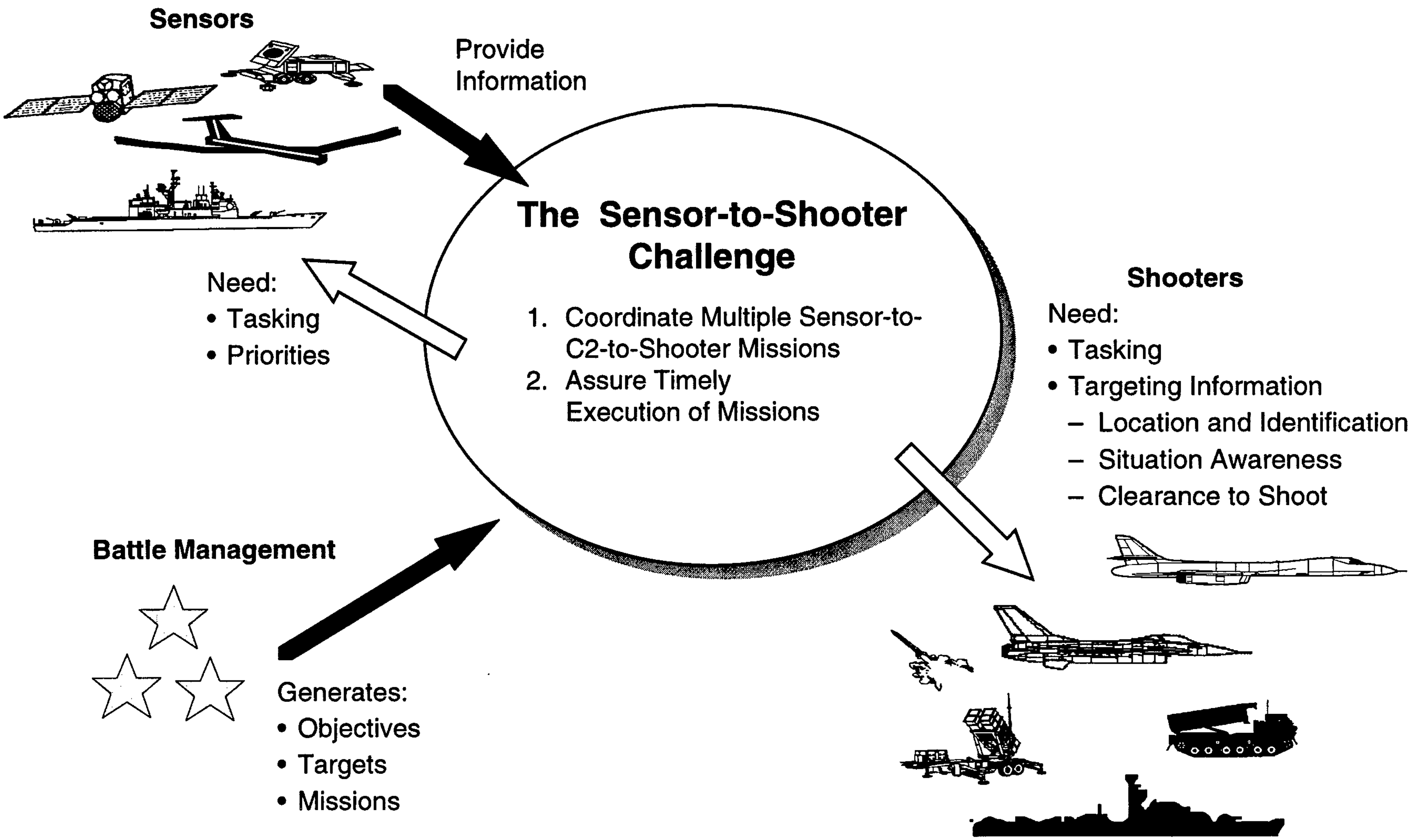
1. Executive Summary

Definition and Scope
The Challenge



Definition and Scope
The Challenge

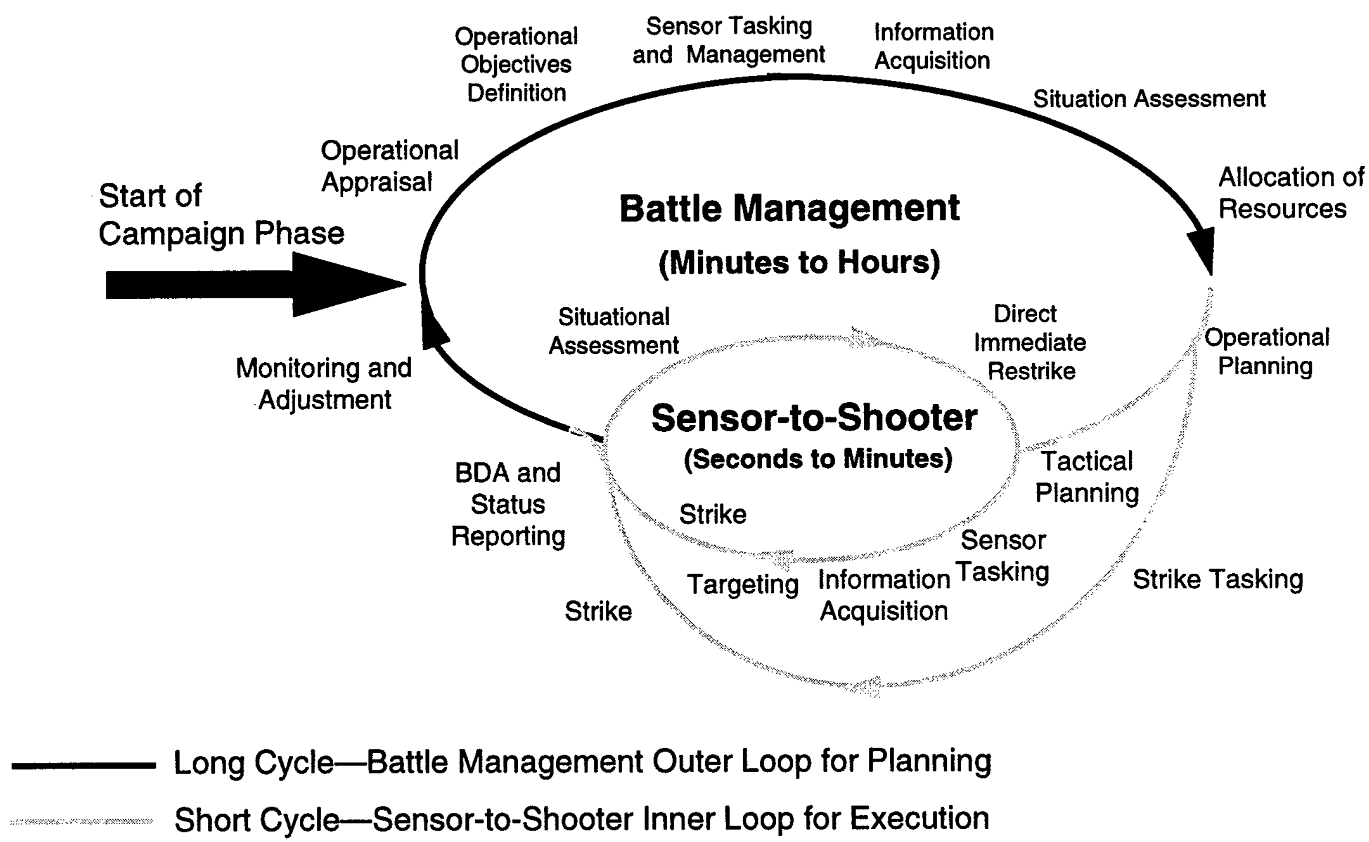
Effectively executing combat operations in a joint force environment involving many ground, air, space, and shipboard resources entails two key challenges:

1. From within a universe of many joint force resources, individual sensors and shooters must be tasked and provided with the necessary priorities and targeting information needed to carry out multiple specific missions against multiple specific targets to achieve all of the battle manager's objectives. The development and maturation of processors to assist in decision making and optimization of finite sensor and weapons assets is the first of two key challenges. This challenge is referred to in this report as *coordination of missions*.

2. For each individual mission, the information linkages must be established between sensors and shooters to enable the *timely execution of missions*, especially time-critical missions. Because, ideally, the sensors can be time shared among many shooters (in addition to the battle manager), effective and efficient implementation of these linkages and the ability to pass information through them will inevitably require the establishment of execution controllers performing real-time or near real-time C2 operations. The development of this operational architecture is discussed subsequently in the context of the needed development timeline.

In this environment, the key operational concept required is one of distributed command and control, with an execution controller for each sensor-to-shooter execution team (which is really a sensor-to-C2-to-shooter team) performing many of the same functions that the battle manager performs. However, the sensor-to-shooter team plans *how* the mission is to be executed, whereas the battle manager plans *what* will be executed. Thus, the C2 for each sensor-to-shooter team requires functional capability similar to that of the battle manager, but for an increased depth of detail spanning a reduced breadth of area of interest and having a much stronger focus on the timeliness of the information versus its completeness.

Operational Concept
Integrated, Target-Focused Operations



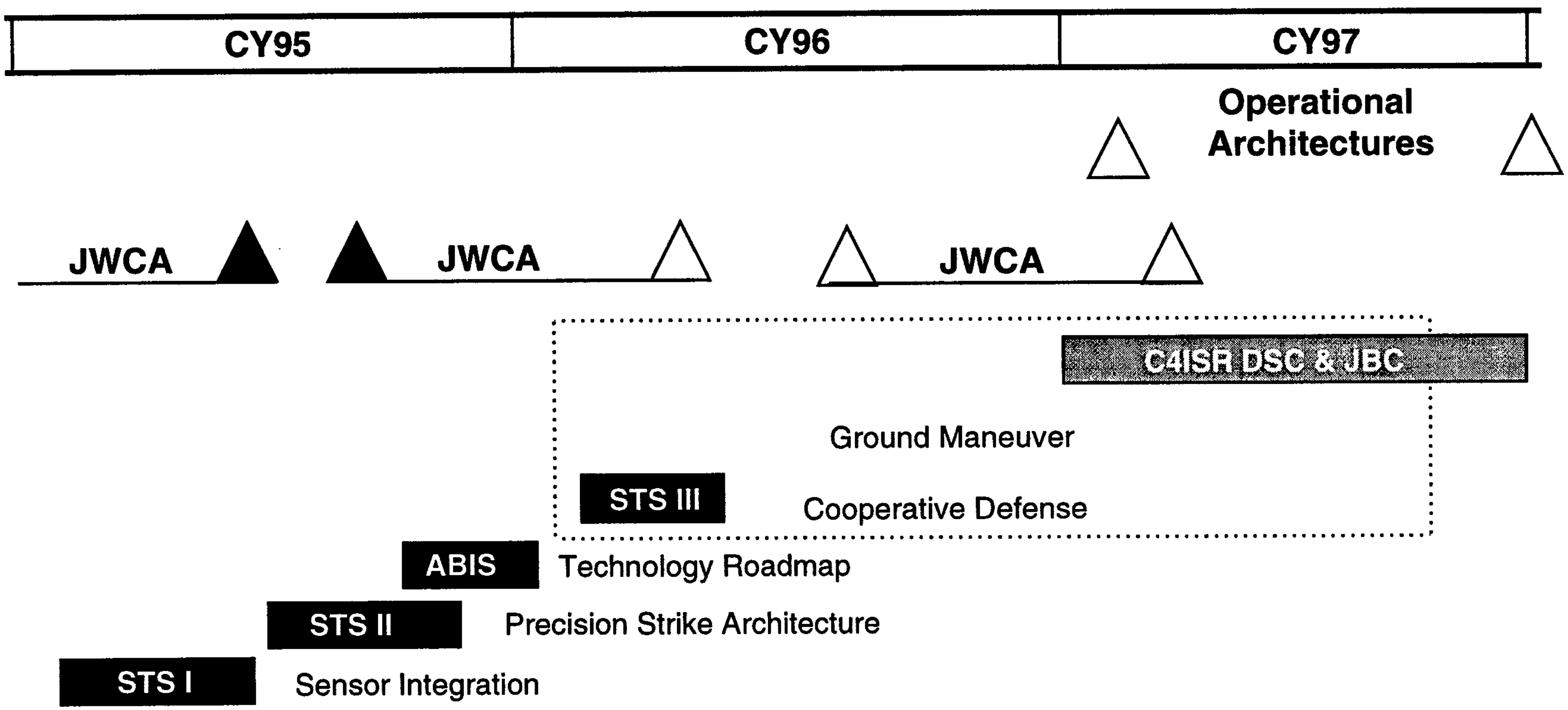
- Autonomous Operations for Fleeting and Maneuvering Targets
- Synchronized Operations for Fixed and Slower Targets

Operational Concept
Integrated, Target-Focused Operations

This nested loop flow model of the Sensor-to-Shooter (STS) Operational Concept will be used in subsequent discussions of STS operations. The outer loop, which represents the longer cycle of battle management operations, splits into two branches, one branch containing the inner loop of sensor-to-shooter operations as a special case. Key observations about the nature of the STS operations follow:

- Sensor-to-shooter operations include many of the same functions in battle management operations (e.g., sensor tasking and information acquisition). This is so because the sensor-to-shooter operations begin when the mission is assigned to the mission leader. At this point, the *sensor-to-shooter* execution team (sensors, shooters, and execution controllers) must perform the same functions in planning *how* the mission is to be executed that the battle managers performed in planning *what* will be executed. Therefore, the sensor-to-shooter team requires the same functional capability as the battle manager, but for an increased depth of detail spanning a narrower area of interest. Although it has a different emphasis on timeliness and level of detail, this functional commonality with battle management is the essence of the sensor-to-shooter challenge.
- Sensor-to-shooter operations are basically of two types, those that are executing the preplanned ATO (that is, the outer loop including the lower branch) and those that are providing assets for highly responsive and autonomous operations against fleeting targets (that is, the fast, seconds to minutes, inner loop). These are discussed in detail in subsequent sections.
- Although it is not obvious from the figure, a key element of integrated sensor-to-shooter operations is the fact that there are multiple cases of these executing elements operating simultaneously. This means the battle manager must plan the synchronized operations of several hundred missions while enabling dozens of highly responsive and autonomous missions against fleeting targets.
- None of the elements of any specific sensor-to-shooter team are necessarily dedicated to a single mission for an entire sortie. On the contrary, for maximum effectiveness in the entire battlespace, sensor sorties in particular will be time shared across many missions.

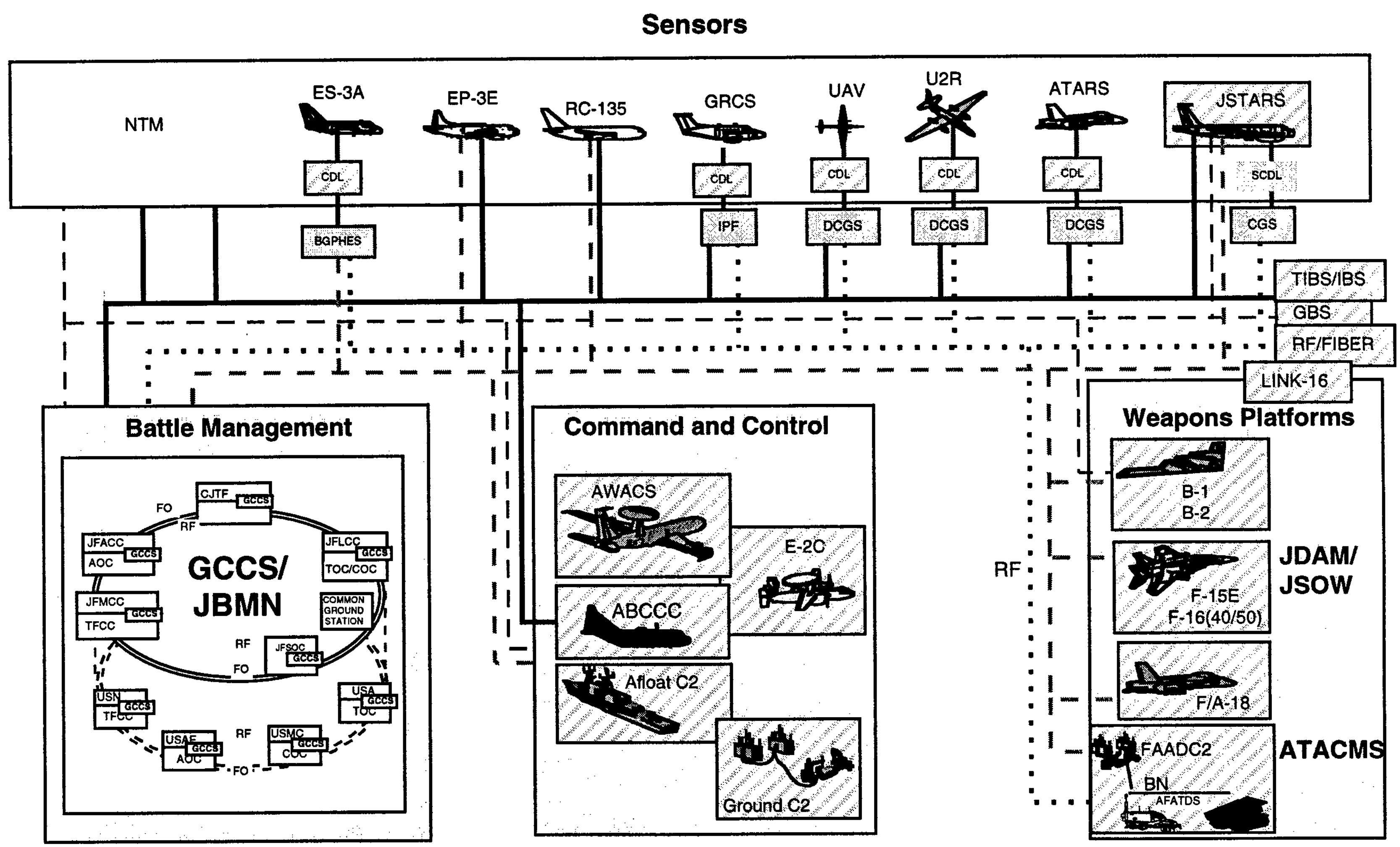
Operational Architecture Development Timeline



Operational Architecture Development Timeline

This figure presents the overall schedule for developing operational architectures. As illustrated, the precision strike architecture has been completed and is in the process of being implemented. Subsequent steps are to include ground maneuver and cooperative defense operations in the operational architecture for implementation. Also depicted are the ABIS study's integration with these efforts and the eventual use of the C4ISR Decision Support System and Joint Battle Center for follow-on technical assessments.

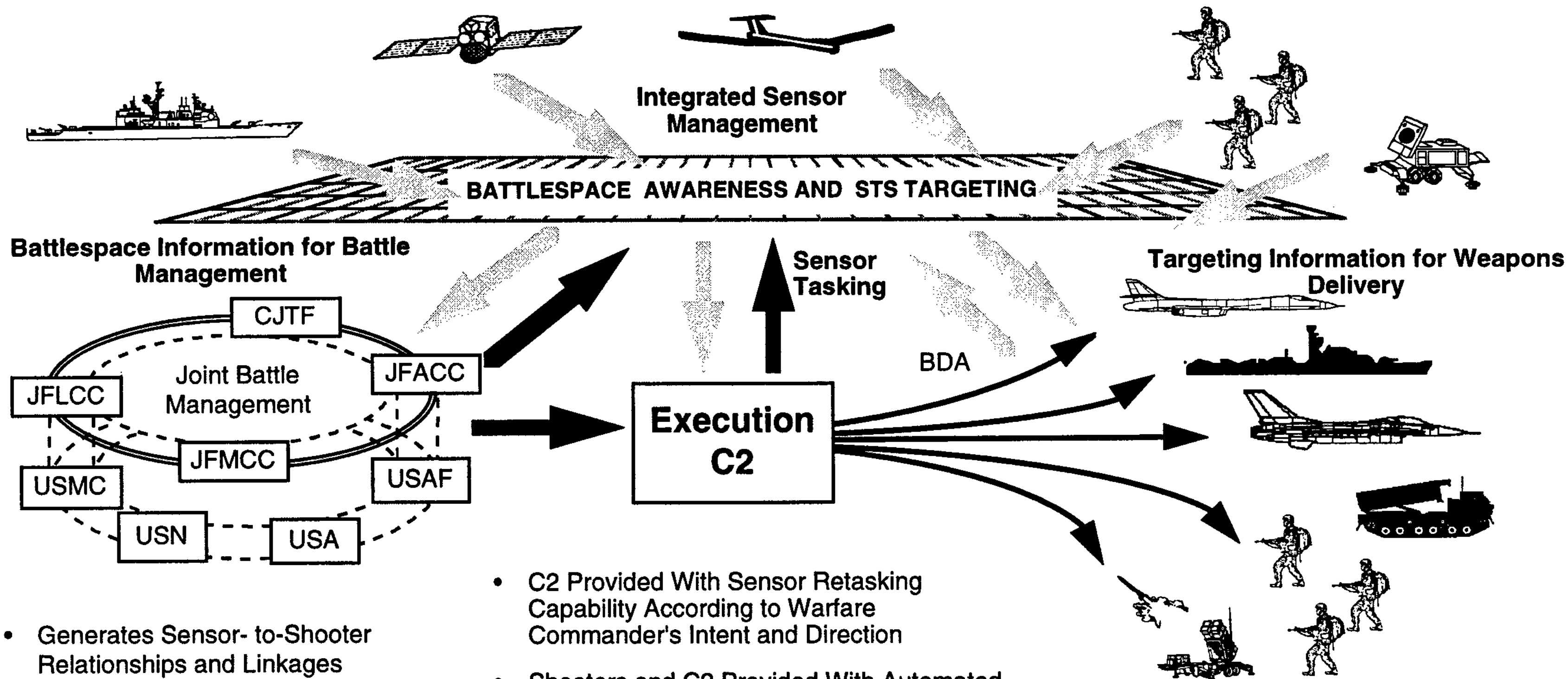
Proposed 2000–2005 C4I Precision Strike Architecture



Proposed 2000–2005 C4I Precision Strike Architecture

The future Precision Strike Architecture is a product of previous J6 Sensor-to-Shooter series of ongoing studies as shown in the preceding figure. For each mission, the information linkages, such as those recommended in this chart, must be established between sensors and shooters to enable the timely execution of missions, especially time-critical missions against combat situations (against fleeting targets such as multiple rocket launchers and Theater Ballistic Missile TELs). Ideally, national, theater, and tactical sensors can be time shared among many shooters (in addition to the battle manager). Effective and efficient implementation of these linkages and passing information through them will inevitably require the establishment of information/collection managers performing real-time or near real-time C2I operations. The development of this operational sensor-to-target pairing architecture is discussed subsequently in the context of the needed development as one of the critical technology focus areas.

System Attributes Parallel, Fast, Dynamic



- Generates Sensor- to-Shooter Relationships and Linkages

- C2 Provided With Sensor Retasking Capability According to Warfare Commander's Intent and Direction
- Shooters and C2 Provided With Automated Tools To Use Any Available Sensor Data, Regardless of Ownership, for Real-Time Target Recognition and Identification

- Shooters Obtain Latest Targeting Information in Displays Suitable for Immediate Execution
- Shooters Provide BDA to Grid for Fusion and Dissemination

LEGEND

Command

Information

System Attributes

The key attributes of the proposed sensor-to-shooter system concept are that they are parallel, fast, and dynamic, versus the current characterization as serial, slow, and nonresponsive. These capabilities will be enabled largely by key elements of the Grid concept, providing battlespace awareness, that is, simultaneous access to battlespace information by shooters and execution controllers as well as by battle managers. With the black arrows indicating command and the other arrows indicating information flow, the figure shows that future operations will separate the information flow from the command cycle. This is necessary to achieve the desired responsiveness. Furthermore, this characteristic is also a major driver in the need for dynamic planning capabilities and parallel operations.

In the proposed system concept, the sensors will continuously input new information into battlespace awareness databases while both executing elements (shooters and controllers) and battle managers will simultaneously be able to retrieve information or have it automatically retrieved and formatted into the appropriate applications/displays. In this manner, today's conflict of competing sensor tasking will be resolved using integrated sensor management techniques. Although the battle manager is seeking battlefield information throughout the entire battlespace, the shooters are seeking targeting information. This means that the shooter needs target location and identification, situation awareness in the target area, and clearance to shoot. Primarily, current shooters do not have adequate situation awareness in the target area. The connectivity and access achieved through implementation of the Grid will provide situational awareness, thus enabling shooters to execute the sensor-to-shooter operations successfully.

Sensor-to-Shooter Important Capabilities

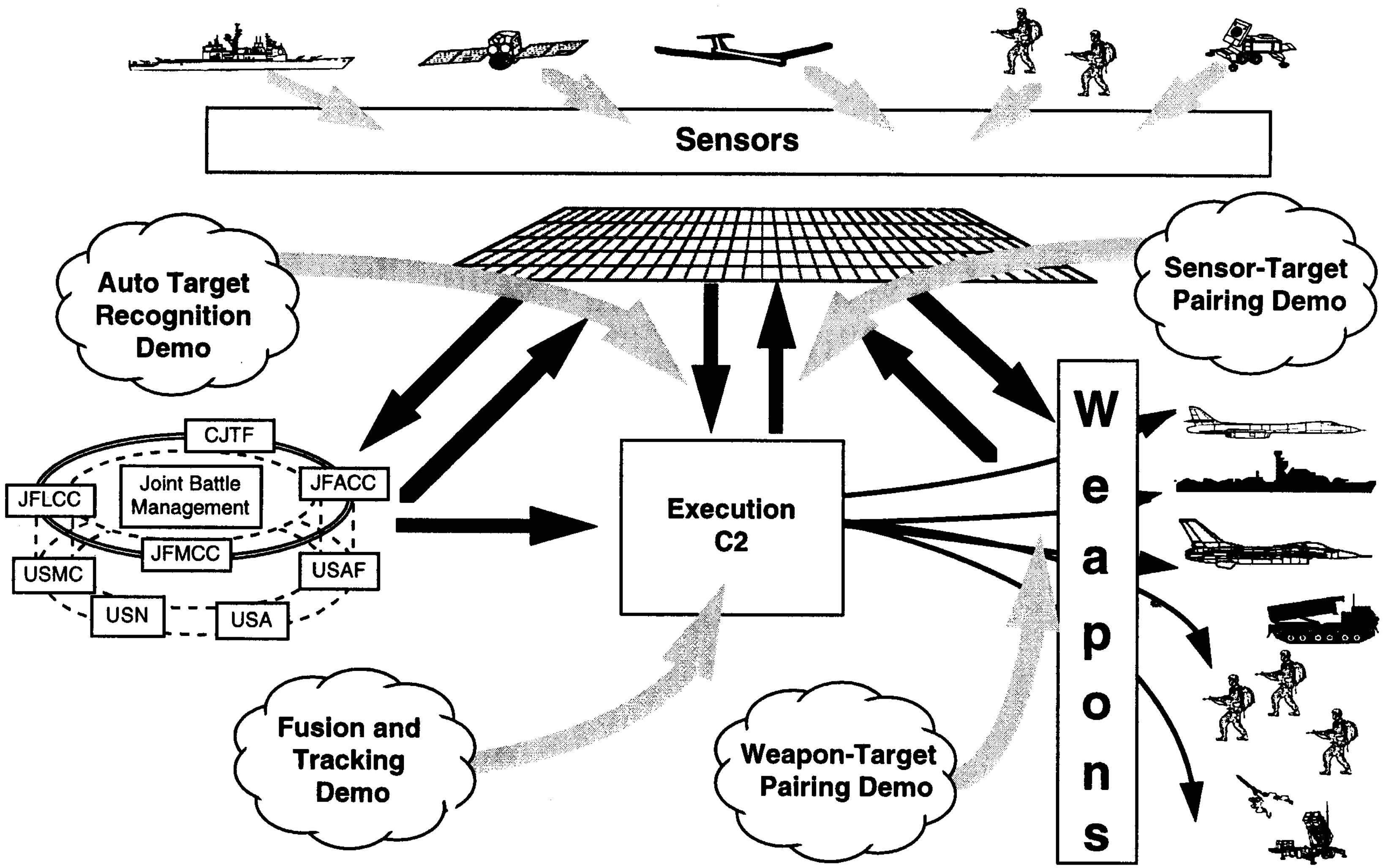
- Execution Control Is the Critical Function for Conducting Effective Sensor-to-Shooter Operations, Requiring Two Operational Capabilities:
  - Coordination of Missions—Preplanned and Time Critical
    - » Delegated Execution to Linked Force Package of C2, Sensors, Platforms, and Weapons Operating As Coordinated Units
    - » Command Authority and Targeting Information Focused on Generating and Supporting These Executing Elements
  - Execution of Time-Critical Missions
    - » Mission-Oriented C2/Strike Force Package Elements Work Inside Enemy Optempo Cycle Against Time-Critical Targets
    - » Battle Manager Retains Real-Time Ability To Redirect Force Package as Situation Changes

Sensor-to-Shooter Important Capabilities

By considering system concepts like those shown in the figure, the 38-member ABIS Sensor-to-Shooter Working Group developed a crosswalk of required operational capabilities for precision strike operations, coordinated air defense operations, and ground maneuver operations. In this process, six detailed vignettes of operational capabilities were developed and assessed to ensure the identification of technologies needed to execute critical operational capabilities. Each of these vignettes represents a situation that will be replicated many times in an operational environment; a number of these vignettes are discussed in this report.

Integrating these required operational capabilities for the three mission areas yielded two critical operational capabilities for execution of sensor-to-shooter operations: the ability to coordinate multiple simultaneous missions (including preplanned execution of the ATO/ITO and the highly responsive, autonomous missions against time-critical targets), and the ability to execute time-critical operations. In both cases, the need for parallel, fast, and dynamic operations remains a key consideration. Both of these operational capabilities are specifically addressed in subsequent figures, but first the mapping process using four key technology demonstrations is illustrated.

Key Opportunities for Near-Term Demonstrations



Key Opportunities for Near-Term Demonstrations

The four key technology demonstrations form key cross-service and cross-mission themes of technologies needed to solve operational limitations. As depicted in the figure, these demonstrations will enhance the shooter's effectiveness by giving the execution controller the tools and capabilities needed to enable time-critical, shooter-focused decisions and to execute these decisions in a joint environment.

These demonstrations take several forms. Some will be new demonstrations proposed for consideration with other proposed FY 97 ACTDs. Others will leverage existing proposed demonstrations with endorsements and, in selected instances, expansion of scope to include both multiple services and expanded mission areas.

The key characteristics of the proposed demonstrations are that they allow tactical warfighters to address targets in parallel, and employ dynamic and fast breaking tactical situations that will be typical of local regional conflicts, major regional conflicts and contingency operations of the future.

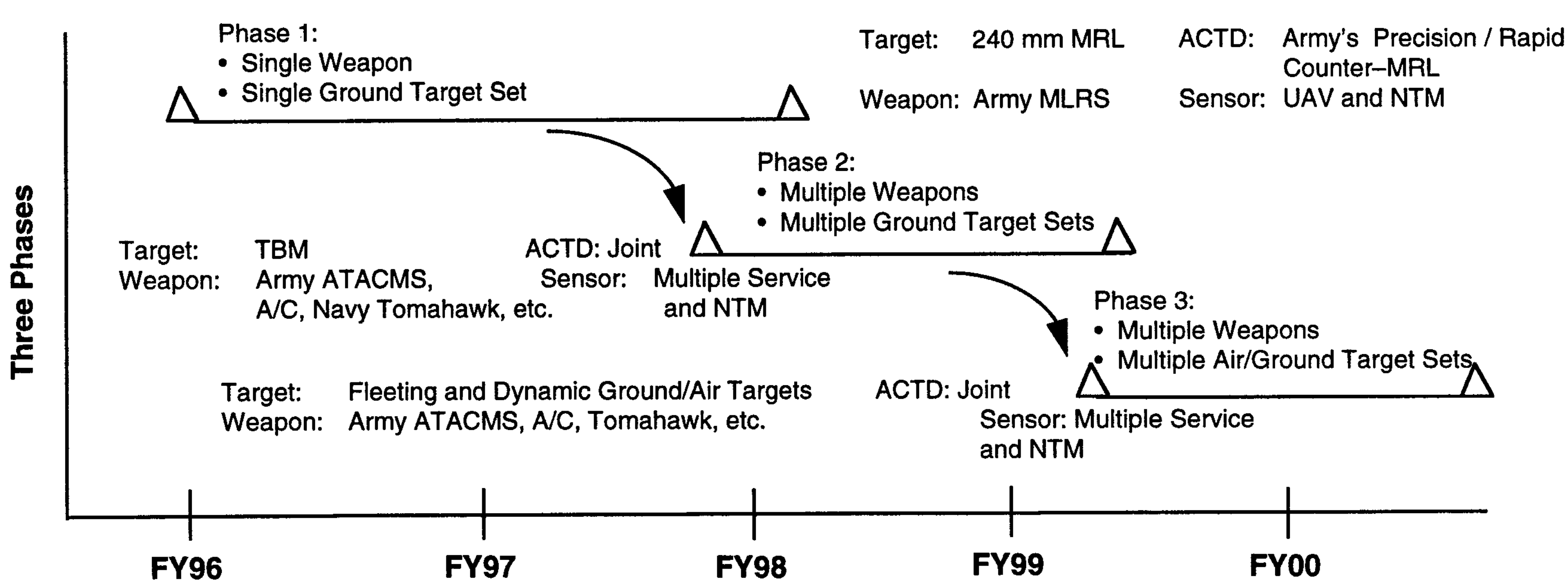
In the proposed demonstrations, sensors will continuously input new information into battlespace awareness databases that both executing elements (shooters and controllers) and battle managers will be able to access.

The following figures expand each of these areas into a technology roadmap that provides a candidate initial plan of action (defining each phase with target class, weapons systems, and key junctures along the critical path). These roadmaps are not unique—any of several approaches could achieve the same ends. However, to fulfill the goal of the ABIS study, at least one approach to achieve the desired ends is presented for each case.

Automated Weapon-to-Target Pairing Technology Demonstration Roadmap

Objective: Against a Highly Mobile Target Set, Demonstrate Automated Pairing With Weapons Systems Optimized to Destroy Ground and Air Targets

Challenges:
- Resource Allocation/Optimization
- Collaborative/Distributive Planning



Automated Weapon-to-Target Pairing Technology Demonstration Roadmap

The first recommended demonstration is Weapon-to-Target Pairing. This capability will enable the execution controller to quickly select and allocate joint force weapons that are available, can reach the target in both range and in timeliness, and have adequate lethality to achieve the commander's intent. Because the execution controller must execute several sensor-to-shooter missions essentially simultaneously, the capability to execute against multiple target sets is necessary.

It is recommended that the demonstration have three phases:

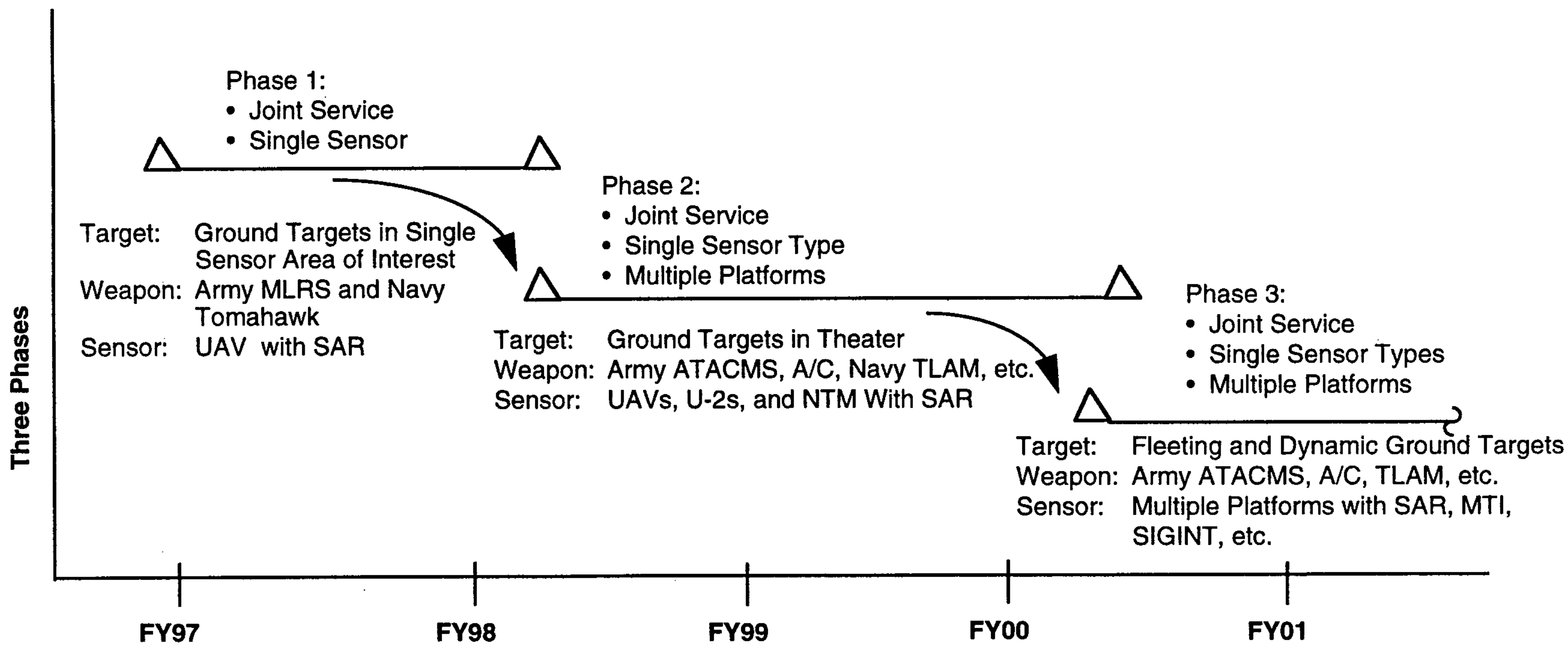
- Phase 1—Single weapon versus a single ground target set
- Phase 2—Multiple weapons versus multiple ground target sets
- Phase 3—Multiple weapons versus multiple ground and air target sets.

The first phase is essentially the same demonstration capability planned by the Army's Precision–Rapid Counter MRL ACTD against 240 mm multiple rocket launchers. Therefore, the primary purpose of this recommendation is to initiate early planning for logical extensions of the ACTD into joint force capabilities against multiple arrays of ground targets, followed by an extension enabling an integrated force versus both ground and air targets.

Automated Sensor-to-Target Pairing Technology Demonstration Roadmap

Overall Objective: Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management

Challenges:
- Decision and Estimation Theory
- Constrained Resource Allocation



Automated Sensor-to-Target Pairing
Technology Demonstration Roadmap

The second demonstration is similar to the first, but focuses on the problem of competition for sensors, that is, a Sensor-to-Target Pairing demonstration. This capability will enable the execution controller to select and allocate time slots of sensor capabilities and dedicate them, for a specific period of time, to individual missions in which shooters need current situation awareness. However, while the shooter support must be achieved in a timely manner, the impact of dynamic sensor retasking must be minimized so that the overall surveillance coverage of the target area is still achieved, thereby achieving the battle manager's information requirements.

This demonstration is inherently a joint demonstration because all key theater sensors are joint service sensors. Therefore, three phases are suggested:

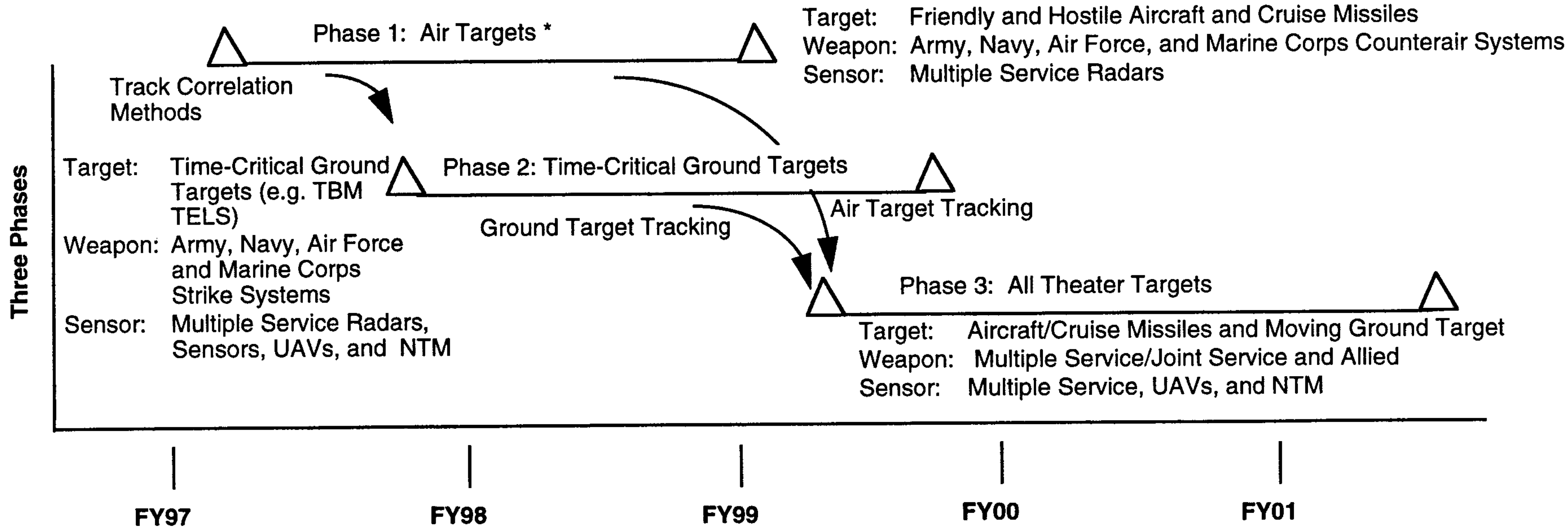
- Phase 1—Single sensor (imagery) and single platform (UAV)
- Phase 2—Single sensor type (imagery) and multiple platforms (UAVs, U-2s, and overhead assets)
- Phase 3—Multiple sensor types (imagery, SIGINT, MTI, etc.) and multiple platforms.

Phases 1 and 2 include elements similar to several proposed ACTDs. These are strongly endorsed. However, several dimensions must be added to address all of the relevant issues: for example, sensor pointing only versus redirecting flight paths, multiple orbit and multiple day optimization of target information.

Integrated Fusion/Target Tracking Technology Demonstration Roadmap

Objective: Demonstrate the Ability To Correlate and Fuse a Diversity of Sensor Information and Generate Birth-to-Death Target Tracks Spanning the Range of Target Behaviors (Emission, Moving, or Stationary)

Challenges:
- Model-Based Reasoning
- Bayesian Decision/Estimation
- Multihypothesis Tracking
- Case-Based Reasoning
- Expert Systems
- Statistical Prediction/Correction
- Multispectral Decisions
- Data Representation Structures



* ABIS STS review designated Navy CEC as foundation for Phase 1.

Integrated Fusion/Target Tracking Technology Demonstration Roadmap

The Integrated Fusion/Target Tracking demonstration focuses on developing birth-to-death tracks of hostile targets. This capability entails correlation of tracks from different sensors of the same type and different types of sensors tracking the entire spectrum of target behaviors. A key capability is the development and maintenance of a single, unique-track ID. Through the CEC program, the Navy is already developing these capabilities for air targets. Consequently, these track management methods should be extended to ground targets and eventually integrated into a complete air-ground display of the battlespace by mission areas.

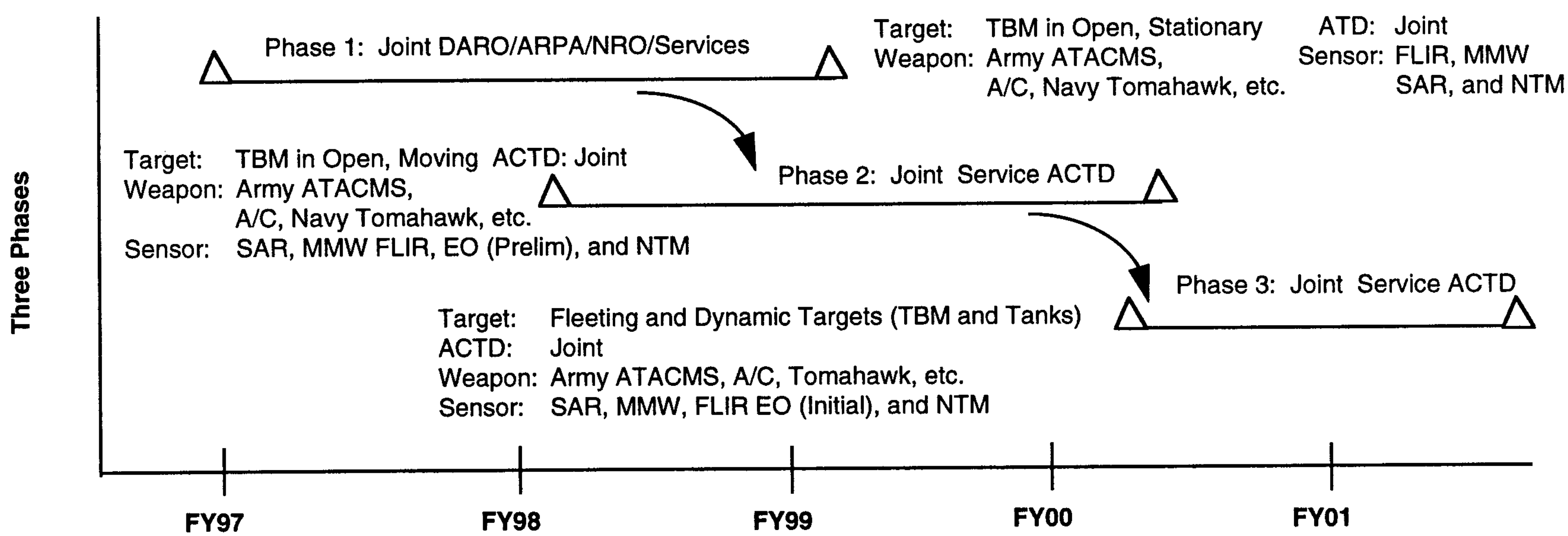
As illustrated in the accompanying figure, it is proposed that the demonstration have three phases:

- Phase 1—Air targets
- Phase 2—Ground targets
- Phase 3—Integrated air–ground targets.

Automated Target Recognition Technology Demonstration Roadmap

Overall Objective: Against a High Value Target Set, Demonstrate Automated Target Recognition Linked With Weapons Systems

Challenges:
- Image Understanding
- Pattern Recognition
- Moving Target Recognition
- Spatial Reasoning
- Template Matching
- Model-Based Recognition
- Temporal Reasoning
- Probabilistic Reasoning



Automated Target Recognition
Technology Demonstration Roadmap

The Automated Target Recognition demonstration focuses on the problem of rapid detection and recognition of target behaviors in multispectral signature regimes. Key MOEs are the time to detect and recognize relevant targets with high probabilities of success and low false alarm probabilities. An integrated measurements and target behavior characterization program is also a requirement for building a meaningful library of target signatures that can be used at any of several nodes in the end-to-end sensor-to-shooter "kill chain." The recommended demonstration program is focused primarily on the technology itself, not on the implementation architecture. Thus, this capability can be resident onboard sensors, at intelligence/fusion nodes, and at C2 nodes as well as with the execution controller. Depending on the theater architecture chosen for implementation, this overall capability may be distributed or centralized, parallel or serial, or any of several other alternatives. These implementation issues are not specifically recommended to be addressed in this demonstration. However, when the architecture has been selected, the technology implementation can be partitioned as appropriate.

The demonstration is suggested in three phases, based on complexity of target behaviors and the diversity of spectral signatures and sensors available:

- Phase 1—Temporarily stationary targets, imaging signatures
- Phase 2—Moving and stationary targets, imaging signatures
- Phase 3—Moving and stationary targets, imaging and other signatures.

Key Observations

- The Key Problem Is Competition for Sensor Coverage Between Battle Managers and Shooters
- The Key Solution Is Enabling Distributed Command and Control of Available Sensor Coverage Through:
  - Automated Processing for Management of Time-Intensive Tasks
  - Common Links To Share Coverage by Those Resources

Key Observations

After assessing precision strike, coordinated defense, and ground maneuver operations, the Sensor-to-Shooter Working Group determined that the primary problem hampering sensor-to-shooter operations is the competition for sensors between battle managers and shooters. Historically, the battle manager wins, leaving the shooter with inadequate information to carry out the mission effectively.

As a result, many proposals are under consideration to provide the shooter with real-time imagery. However, the findings of this working group indicate that another answer, that is, enabling a distributed command and control approach, will provide the shooter with the targeting information that is really needed, thereby making the shooter more effective than can be accomplished through inundation with additional information. This solution entails two elements: the development of revised processes (and the tools to support them), and the identification and development of architectures and links providing the needed connectivity. Because a parallel, complementary effort is being conducted under J6I sponsorship, the efforts of the ABIS STS Working Group were focused on the technologies necessary to implement the revised processes.

2. Results

Sensor-to-Shooter Working Group Objectives

- Develop CONOPS and Capability Objectives for Processing, Links, and C2 To Provide:
  - Dynamic Targeting and Cueing
    - Accurately
    - Timely
  - Situational Awareness
    - Localized
    - Tailored to Shooters' Needs
- Identify Key Packages of Enabling Technologies
  - Emerging Information Technologies Related Services
  - Current Demonstrations and Prototypes
  - Additional Future Needs

Sensor-to-Shooter Working Group Objectives

As shown in the figure, the objectives of the ABIS Sensor-to-Shooter Working Group were as follows:

- Initially, develop a concept of operations and operational capability objectives that would be compatible with and would stimulate the implementation of combat operations as conceived in Vision 2010 by the VCJCS.

- Subsequently, identify the key enabling technologies needed to ensure that implementation of Vision 2010 will not be technology limited.

To achieve these objectives, the initial concepts of Vision 2010 were broadened. With the other two working groups, the Battle Management Working Group and the Grid Working Group, compatible, loosely integrated system concepts were developed. Although some unavoidable overlap resulted, in essence, the Sensor-to-Shooter Working Group was responsible for assessing the actual execution of the combat operations, whereas the Battle Management and the Grid Working Groups were responsible for planning and execution management and for information management and dissemination, respectively.

Sensor-to-Shooter Working Group Goals

Identify Key Packages of Enabling Technologies

- Emerging Information Technology Related Services
  - — Current Demonstrations and Prototypes
  - — Additional Future Needs

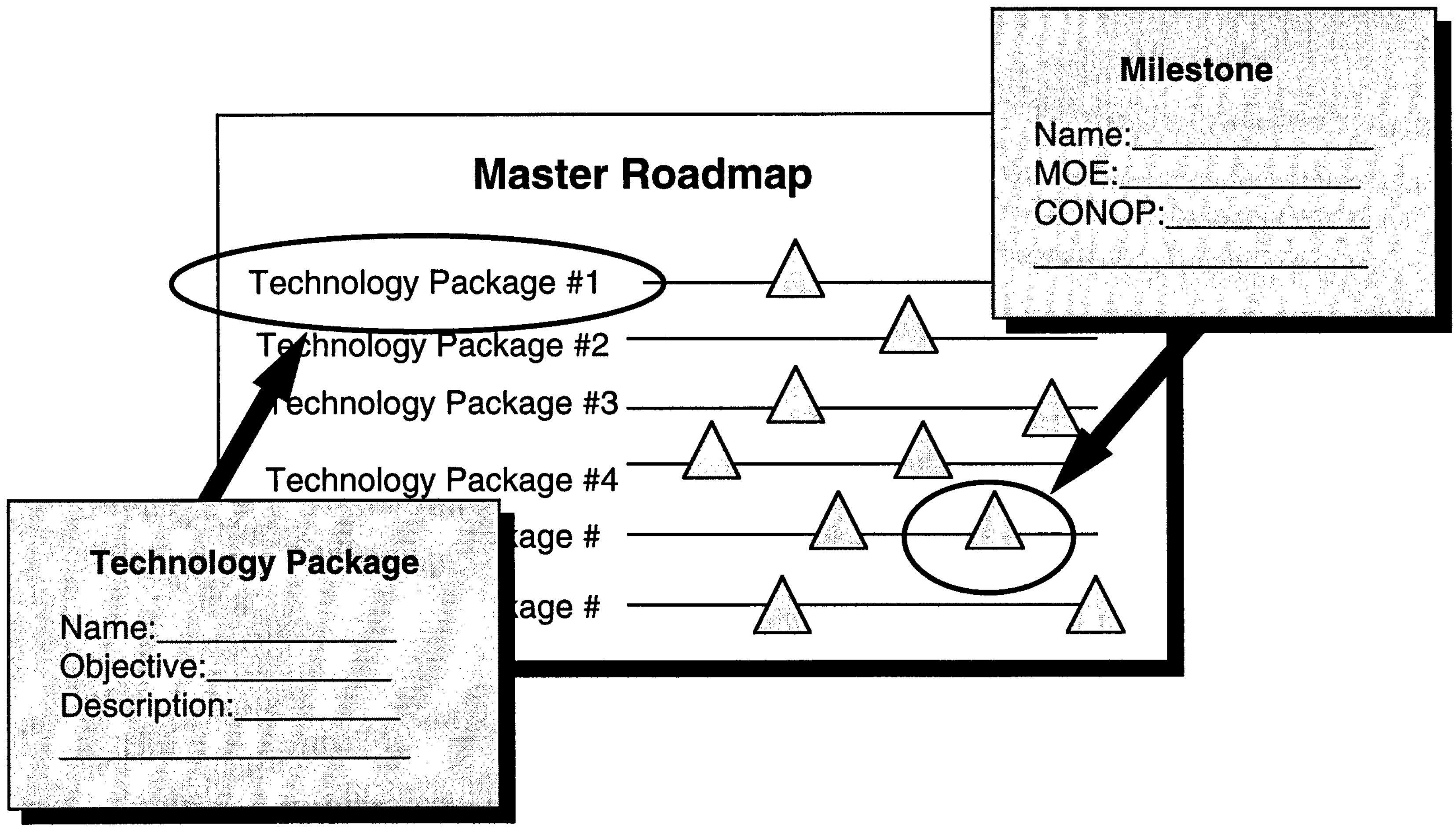
Time-Phased Technology Roadmap

- Sensor-to-Shooter Improvement
- Executing in System-of-Systems Operations Concept

Sensor-to-Shooter Working Group Goals

The specific goals that the Sensor-to-Shooter Working Group undertook for the ABIS study were to identify packages of enabling technologies and then develop an initial set of technology roadmaps. It was envisioned that the roadmaps would stimulate integrated technology-operational thought processes and accelerate C4I technology development in the DoD S&T community. These roadmaps and their supporting logic are the working group's primary products.

Sensor-to-Shooter Working Group Deliverable: Technology Roadmaps



Sensor-to-Shooter Working Group Deliverable: Technology Roadmaps

The purpose of the technology roadmaps is to stimulate the creation of service and DDR&E demonstration programs, specifically focused on developing the operational capabilities necessary to accelerate Vision 2010 implementation. These roadmaps are not intended to be program plans. Rather, they indicate one of several possible rational, systematic approaches to a sequential development of key capabilities. Key capability objectives and associated measures of effectiveness are provided to spur discussion within the science and technology (S&T) community.

Sensor-to-Shooter Working Group Approach

Operational Context
- Precision Strike
- Cooperative Defense
- Ground Maneuver

↓

Broad Concepts
- Precision Strike
- Cooperative Defense
- Ground Maneuver

↓

Important C2I Operational Capabilities
- Precision Strike
- Cooperative Defense
- Ground Maneuver

↓

Mapping of S&T Program

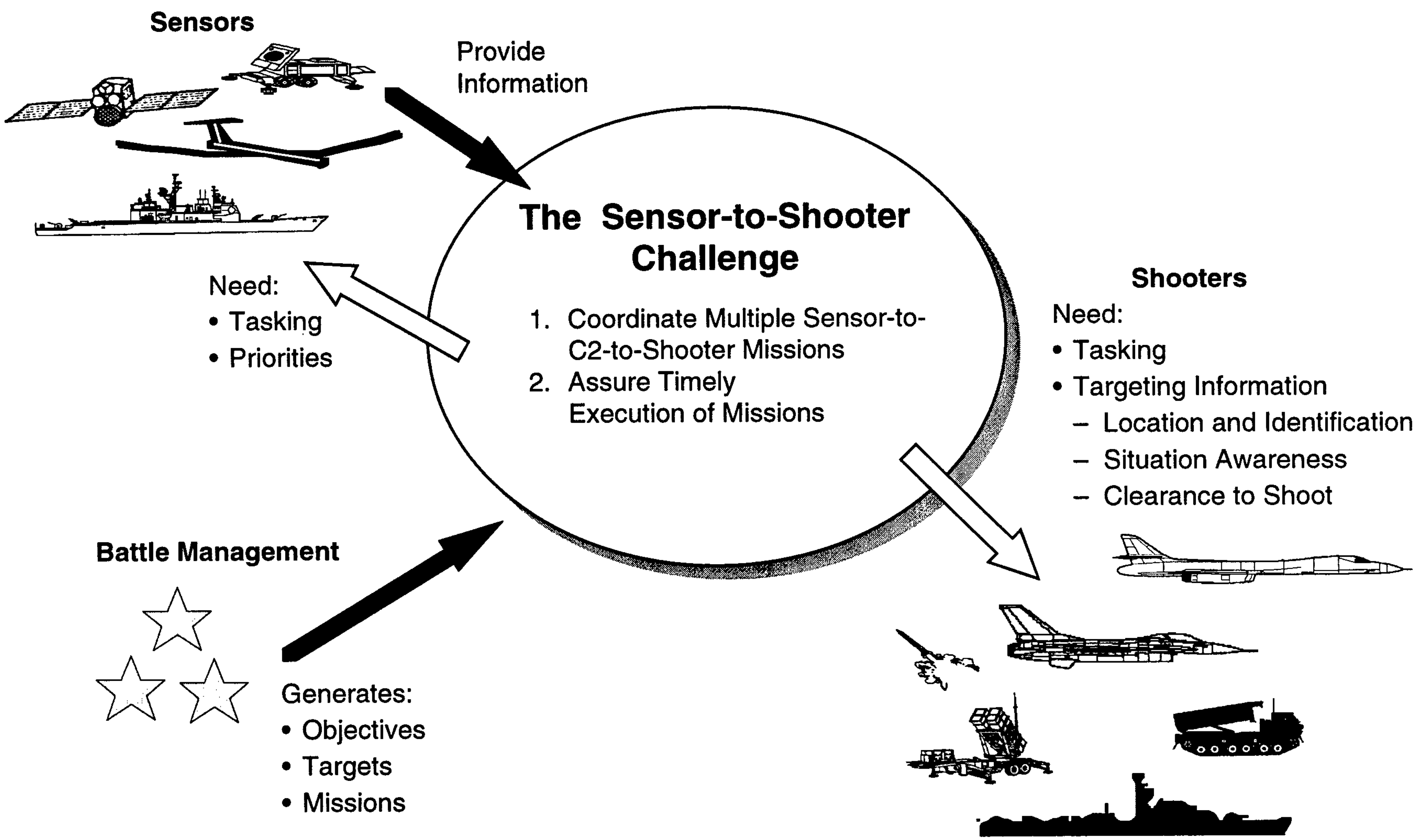
↓

Technology Roadmaps

Sensor-to-Shooter Working Group Approach

The working group's focus for the initial 3 months was to assess possible operational concepts and to simultaneously develop broad concepts for the three mission areas of interest: precision strike, cooperative defense, and ground maneuver. Important C2I operational capabilities needed to achieve the revised operations concepts were defined in operational and functional terms. The working group then crosswalked, or mapped, the current S&T program to identify needed technological thrusts. Finally, technology roadmaps were developed.

Definition and Scope
The Challenge



Definition and Scope
The Challenge

Effectively executing combat operations in a joint force environment involving many ground, air, space, and shipboard resources entails two key challenges:

1. From within a universe of many joint force resources, individual sensors and shooters must be tasked and provided with the necessary priorities and targeting information needed to carry out multiple specific missions against multiple specific targets to achieve all of the battle manager's objectives. This challenge is referred to in this report as *coordination of missions*.

2. For each mission, establish the information linkages between sensors and shooters necessary to enable the *timely execution of missions*, especially time-critical missions. Because, ideally, the sensors can be time shared among many shooters (in addition to the battle manager), effective and efficient implementation of these linkages and passing information through them will inevitably require the establishment of execution controllers performing real-time or near real-time C2 operations.

In this environment, the key operational concept required is one of distributed command and control, with an execution controller for each sensor-to-shooter execution team (which is really a sensor-to-C2-to-shooter team) performing many of the same functions that the battle manager performs. However, the sensor-to-shooter team plans *how* the mission is to be executed whereas the battle manager plans *what* will be executed. Thus, the C2 for each sensor-to-shooter team requires functional capability similar to that of the battle manager, but for an increased depth of detail spanning a narrower area of interest and having a much stronger focus on the timeliness of the information versus its completeness.

Key Study Findings

- The Key Problem Is Competition for Sensors Between Battle Management and Shooters
- The Key Solution Is Enabling Distributed Command and Control Through:
  - Automated Processing for Management of Time-Intensive Tasks
  - Common Links To Share Optimization of Those Resources
- Four High-Payoff Technology Demonstrations Necessary To Advance Toward the Solution Were Identified

Key Study Findings

After assessing precision strike, coordinated defense, and ground maneuver operations, the Sensor-to-Shooter Working Group determined that the primary problem hampering current sensor-to-shooter operations is the competition for sensors between more senior battle managers and shooters. Historically, the battle manager has monopolized tasking of special sensors, leaving the shooter with inadequate information to carry out the mission effectively.

To address that problem, many proposals are under consideration to provide the shooter with real-time imagery. However, the findings of this working group indicate that another answer, that is, enabling a distributed command and control approach, will provide the shooter with the targeting information really needed, thereby making the shooter more effective than can be accomplished through inundation with additional information. This solution entails two elements—developing revised processes (and the tools to support them), and identifying and developing architectures and links that provide the needed connectivity. Because a parallel, complementary operational architecture effort is being conducted under J6I sponsorship, the ABIS STS working group focused on the technologies necessary to implement the revised processes.

The working group found that the best way to increase the effectiveness of the shooter was through enabling enhanced effectiveness of the execution controller. Consequently, four areas for technology demonstrations are recommended, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified: coordination of multiple missions and execution of time-critical missions.

Sensor-to-Shooter Important Capabilities

Execution Control Is the Critical Function for Conducting Effective Sensor-to-Shooter Operations, Requiring Two Operational Capabilities:

- Coordination of Missions—Preplanned and Time-Critical
  - Delegated Execution to Linked Force Package of C2, Sensors, Platforms, and Weapons Operating as Coordinated Units
  - Command Authority and Targeting Information Focused on Generating and Supporting These Executing Elements
- Execution of Time-Critical Missions
  - Mission-Oriented C2/Strike Force Package Elements Work Inside Enemy Optempo Cycle Against Time-Critical Targets
  - Battle Manager Retains Real-Time Ability To Redirect Force Package as Situation Changes

Sensor-to-Shooter Important Capabilities

Considering systems concepts like those shown, the 38-member ABIS Sensor-to-Shooter Working Group devoted 2 months to developing a crosswalk of required operational capabilities for precision strike operations, coordinated air defense operations, and ground maneuver operations. In this process, six vignettes of operational capabilities were developed in some detail and assessed to ensure the identification of technologies needed to execute critical operational capabilities. Each of these vignettes represents a situation that will be replicated many times in an operational environment.

Integrating and summarizing these required operational capabilities for the three mission areas listed above yielded two critical operational capabilities needed to execute sensor-to-shooter operations: the ability to coordinate multiple simultaneous missions (including both preplanned execution of the ATO/ITO as well as the highly responsive, autonomous missions against time-critical targets) and the ability to execute time-critical operations. In both cases, the need for parallel, fast, and dynamic operations remains a key consideration. Both of these operational capabilities are specifically addressed in subsequent figures, but first the mapping process is addressed with an example used for illustration.

Sensor-to-Shooter
Execution of Time-Critical Missions

Goal

Provide a dedicated force package of shooters with sufficient timely and relevant information to enable successful prosecution of time-critical targets.

Critical New Functional Capabilities

- Theater Intelligence Processing for Broadcast
- Rapid, Accurate Targeting
- Rapid, Accurate BDA
- Real-Time Collaborative Planning
- Force Status and Execution Following
- Automatic Weapon Target Pairing
- ISR Management and Integration

Current Limitations

- Targets Appear After Force Package Commitments, Pop-Up Targets, Movements Cycles
- Execution Status Unknown
- Inability for Timely Counteraction to Target Reaction
- Inadequate Coordination
- Battle Management Reluctant To Release Information
- Different Information Needs for Different Users
- Simultaneous Pulls on Sensors
- Insufficient Connectivity
- Lack of Sensors
- Man-Intensive BDA
- Sensor Management Not Tied to Commander's intent

Needed Technology

- Wideband Communications and Interconnectivity
- Real-Time, Cognition Aiding Displays
- Automated Planning/Decision Support Tools
- Data Interoperability/Synchronization
- Automated IPB Processes
- Fusion and Integrated Target Tracking
- Automatic Target Recognition
- Multilevel Security
- ISR Management and Integration Tools

Sensor-to-Shooter
Execution of Time-Critical Missions

This figure summarizes the Sensor-to-Shooter Working Group's assessment of the operational capability Execution of Time-Critical Missions. Note that the technologies are identical to those listed in Coordination of Missions. Although specific quantitative capabilities may differ for the two critical operational capabilities, the overall categories are identical. Details can be found in the remainder of this volume.

Sensor-to-Shooter Coordination of Missions

Goal

Provide a collaborative decision making and planning environment between execution controllers, sensors, and shooters that ensures the coordinated execution of all missions assigned by the Battle Management—from the initial tasking through the execution of the missions.

Critical New Functional Capabilities

- Parallel Dissemination of Intel/BDA to C2 and Shooter
- Theater Intelligence Processing for Broadcast
- Rapid, Accurate BDA
- Force Status and Execution Monitoring
- Rapid, Accurate Target Information (Target Location and Recognition, Situation Awareness in Target Area)
- Automated Weapon to Target Pairing
- Automated Mission to Target Pairing
- ISR Management and Integration

Current Limitations

- Slow Decision and Resource Allocation Process With Regard to Target Cycle Times
- Poor Detection of Fleeting Target Entities in Crowded Battlespace
- Slow Fusion Process
- Best Sensor Information Not Incorporated
- Lack of Sensors
- Man-Intensive BDA
- Sensor Management Not Tied to Commander's Intent

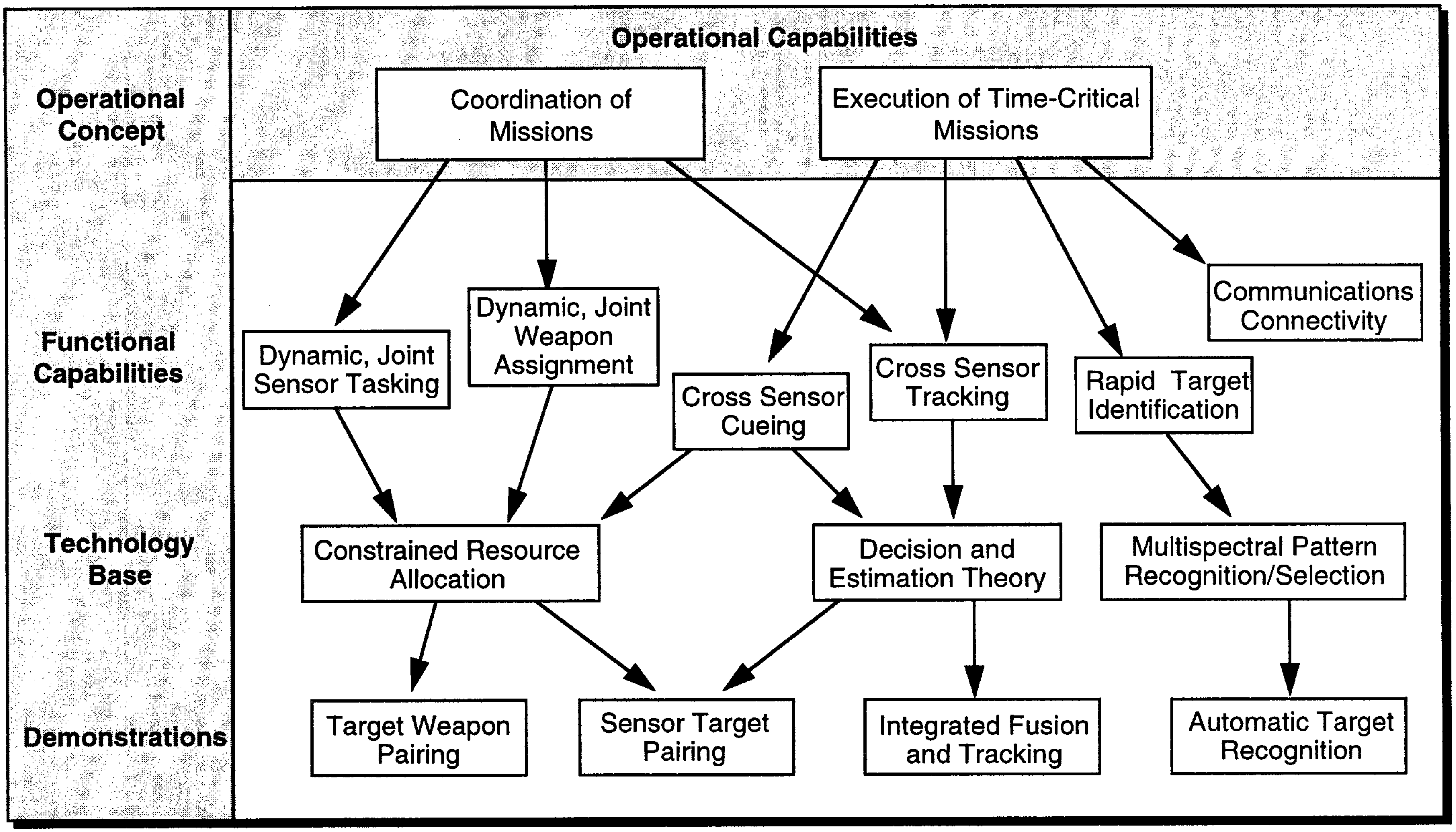
Needed Technology

- Wideband Communications and Interconnectivity
- Real-Time, Cognition Aiding Displays
- Automated Planning/Decision Support Tools
- Data Interoperability/Synchronization
- Automated IPB Processes
- Fusion and Integrated Target Tracking
- Automatic Target Recognition
- Multilevel Security
- ISR Management and Integration Tools

Sensor-to-Shooter
Coordination of Missions

In developing the assessments that led to the definition of the critical operational capabilities, the Sensor-to-Shooter Working Group defined the required operational capabilities (goal), identified current limitations, defined critical new functional capabilities, and subsequently defined critical needed technologies. These steps were followed for each of the six operational vignettes. The anticipated status and maturity of the technologies were assessed by evaluating summary information about currently approved ACTDs and selected information on service ATDs and TAPs made available to the working group. The summary results for Coordination of Missions are presented here.

Sensor-to-Shooter Operational Capability—Technology Mappings



Sensor-to-Shooter Operational Capability—Technology Mappings
Top Four Demonstrations

Following the process specified by the Secretariat, the Sensor-to-Shooter Working Group assessed those functional capabilities required to execute the two operational capabilities of the operational concept. These functional capabilities were then further decomposed and/or grouped into technology areas needing operationally oriented demonstrations to focus the technology into applications that would clearly support the shooter. This was a critical step because many of the technologies are well developed, but are not oriented toward shooter timeframes and areas of interest. Note that the mappings for all of the technologies assessed are not presented in this figure. Only the key technologies that map to the four proposed demonstrations that have applications across battlespace operations are presented.

Major Challenges

Execute Four High-Payoff Technology Demonstrations To Advance Toward the Solution:

- Automated Weapon-to-Target Pairing
- Automated Sensor-to-Target Pairing
- Automated Target Recognition
- Integrated Fusion and Target Tracking

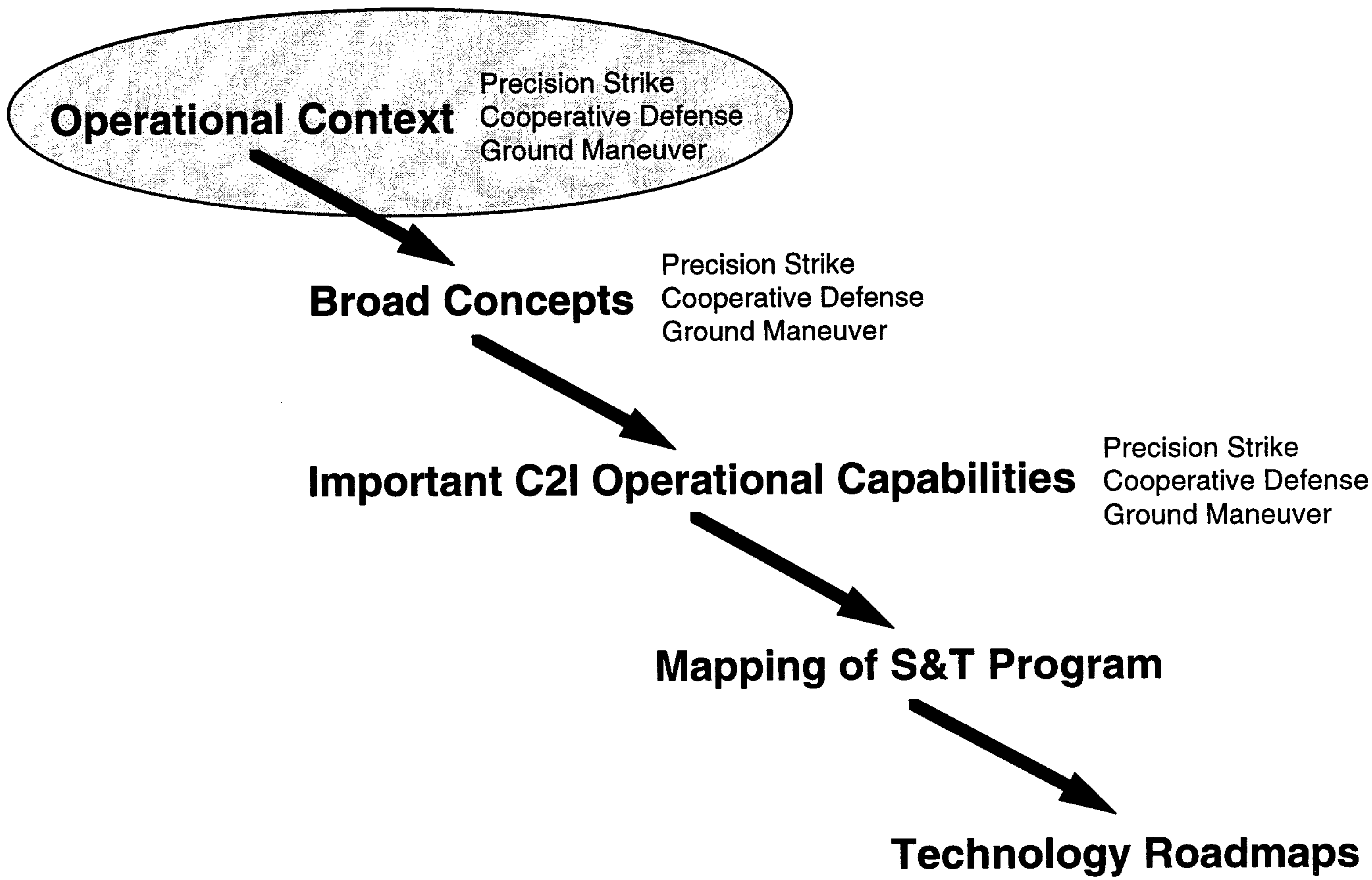
Major Challenges

The working group's findings indicate that the most effective way to enhance the shooter's performance is to enable a distributed command and control approach, that is, implement an execution controller. This approach provides the shooter with the needed targeting information in the most effective manner, without inundating him with irrelevant information.

The working group recommended four areas for technology demonstrations, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified—coordination of multiple missions and execution of time-critical missions. Technology roadmaps were developed for each of these four areas. Development of these capabilities will enhance the overall ability of shooters to execute the intentions of the battle commander by enabling the prosecution of more targets, faster, and more effectively, thereby shortening any hostile engagements significantly. The eventual implementation and fielding of these capabilities will be the real enduring value of these technology demonstrations.

Consequently, four areas for technology demonstrations are recommended: Automated Weapon-to-Target Pairing, Automated Sensor-to-Target Pairing, Automated Target Recognition, Integrated Fusion and Target Tracking. Each of these will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities.

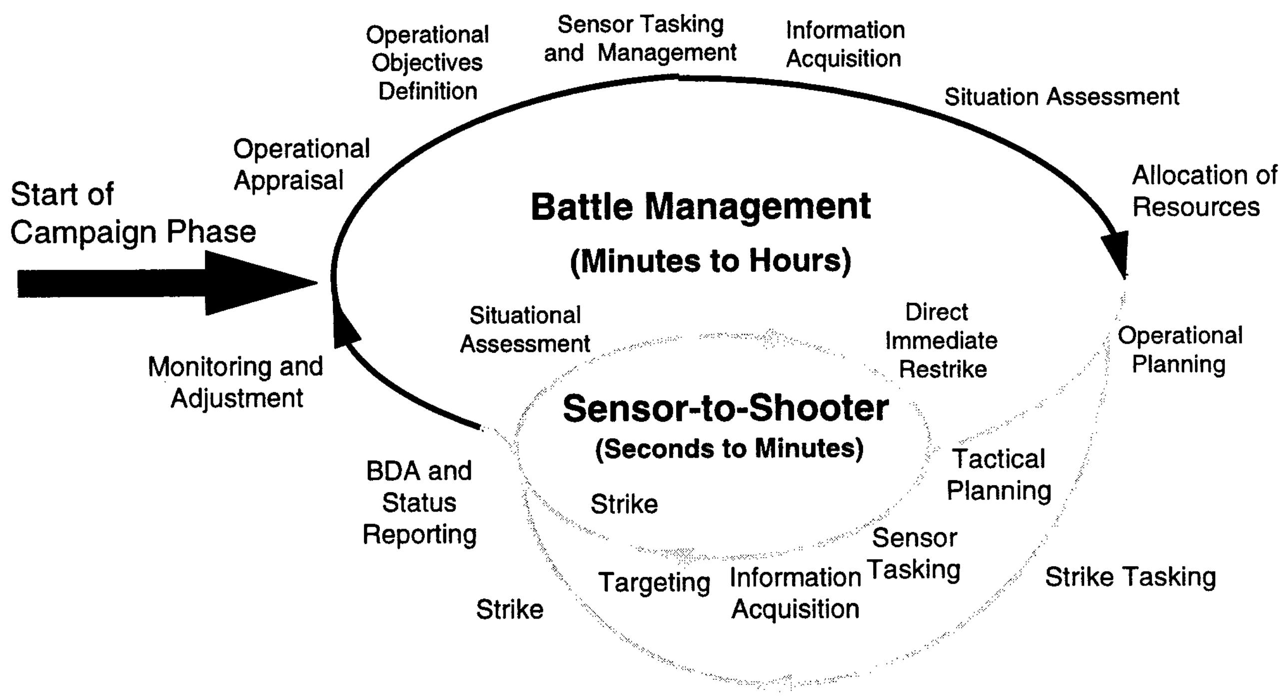
Sensor-to-Shooter Working Group Approach



Sensor-to-Shooter Working Group Approach
Definition of Operational Context and Broad Concepts

The details of the working group's approach follow, beginning with definition of the operational context.

Integrated, Target-Focused Operations



Short Cycle–Sensor-to-Shooter Inner Loop for Execution

- Autonomous Operations for Fleeting and Maneuvering Targets
- Synchronized Operations for Fixed and Slower Targets

Long Cycle–Battle Management Outer Loop for Planning

Sensor-to-Shooter Operational Context

This nested loop flow model of the Sensor-to-Shooter Operational Context is used in subsequent assessments of STS operations. The outer loop, which represents the longer cycle of battle management operations, splits into two branches, one branch containing the inner loop of sensor-to-shooter operations as a special case. Some key observations about the nature of the STS operations are as follows:

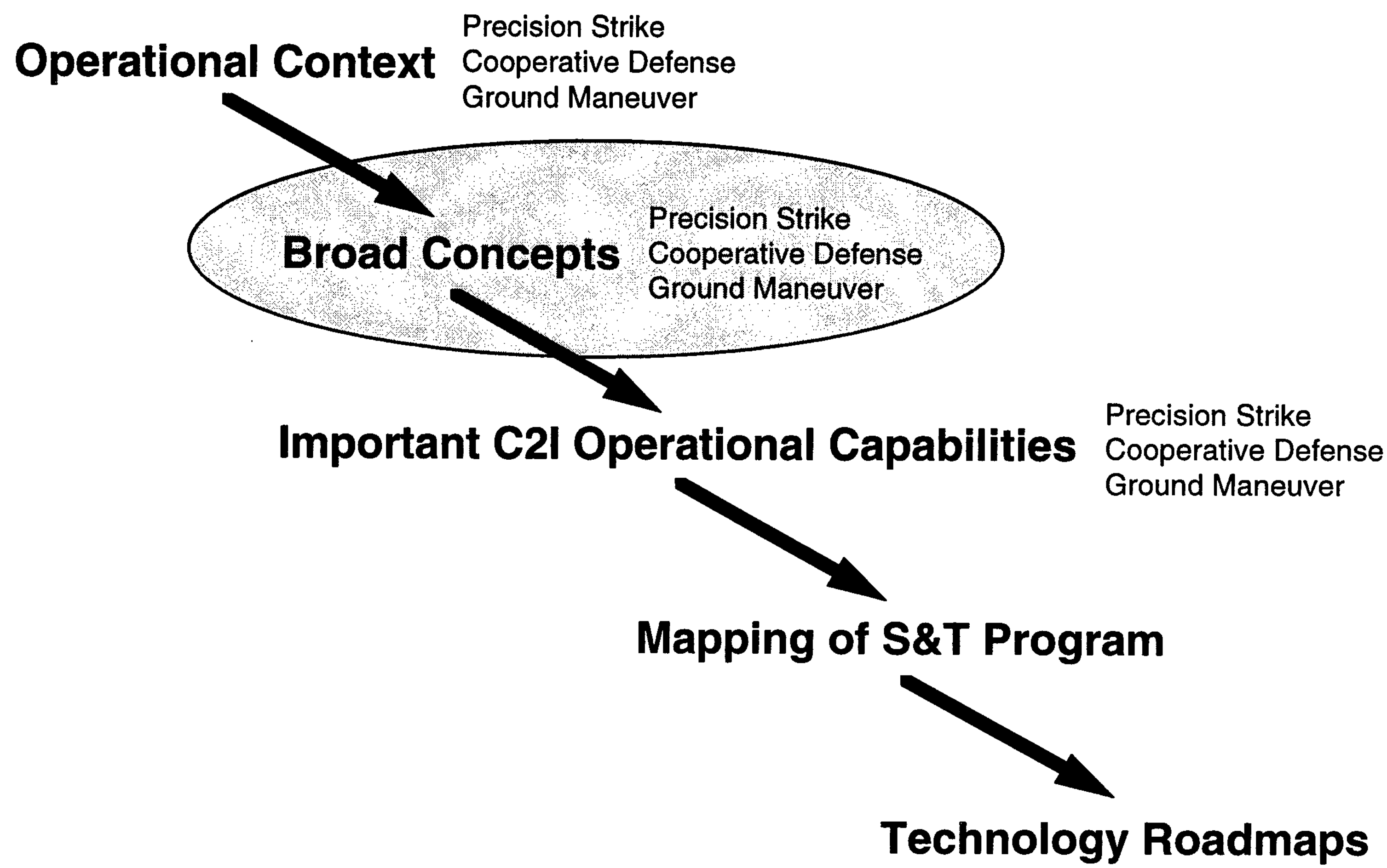
- Sensor-to-shooter operations include many of the same functions in battle management operations (e.g., sensor tasking and information acquisition). This is so because the sensor-to-shooter operations begin when the mission is assigned to the mission leader. At this point, the *sensor-to-shooter* execution team (sensors, shooters, and execution controllers) must perform the same functions in planning *how* the mission is to be executed that the battle managers performed in planning *what* will be executed. Therefore, the sensor-to-shooter team requires the same functional capability as the battle manager, but for an increased depth of detail spanning a narrower area of interest. Although it has a different emphasis on timeliness and level of detail, this functional commonality with battle management is the essence of the sensor-to-shooter challenge.

- Sensor-to-shooter operations are basically of two types, those that are executing the preplanned ATO (i.e., the outer loop including the lower branch) and those that are providing assets for highly responsive and autonomous operations against fleeting targets (i.e., the fast, seconds to minutes, inner loop). These are discussed in detail in subsequent sections.

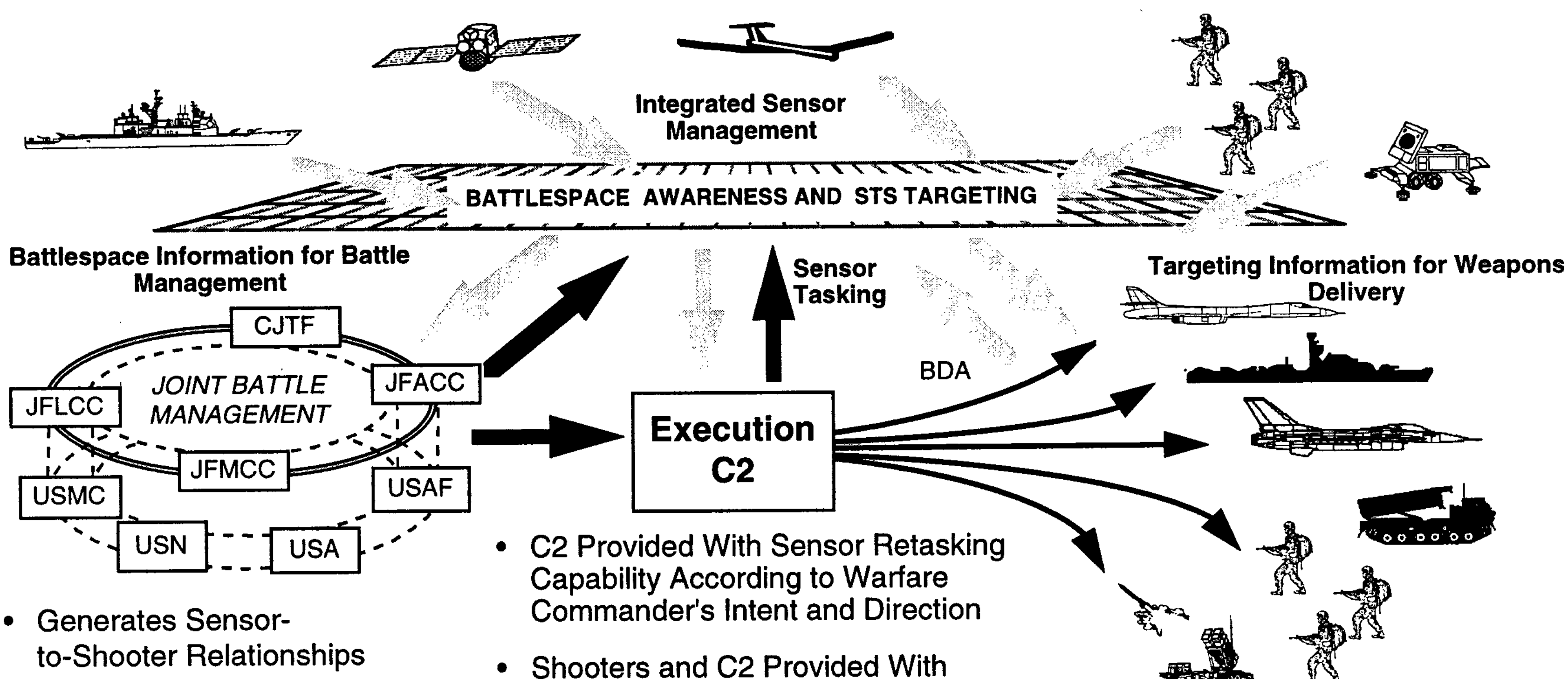
- Although it is not obvious from the figure, a key element of integrated sensor-to-shooter operations is the fact that there are multiple executing elements operating simultaneously. This means the battle manager must plan the synchronized operations of several hundred missions while enabling dozens of highly responsive and autonomous missions against fleeting targets.

- None of the elements of any specific sensor-to-shooter team are necessarily dedicated to a single mission for an entire sortie. On the contrary, for maximum effectiveness in the entire battlespace, sensor sorties in particular will be time shared across many missions.

Sensor-to-Shooter Working Group Approach



System Attributes
Parallel, Fast, Dynamic



- Generates Sensor-to-Shooter Relationships and Linkages
- C2 Provided With Sensor Retasking Capability According to Warfare Commander's Intent and Direction
- Shooters and C2 Provided With Automated Tools To Use Any Available Sensor Data, Regardless of Ownership, for Real-Time Target Recognition and Identification
- Shooters Receive Latest Targeting Information in Displays Suitable for Immediate Execution
- Shooters Provide BDA to Grid for Fusion and Dissemination

LEGEND

Command

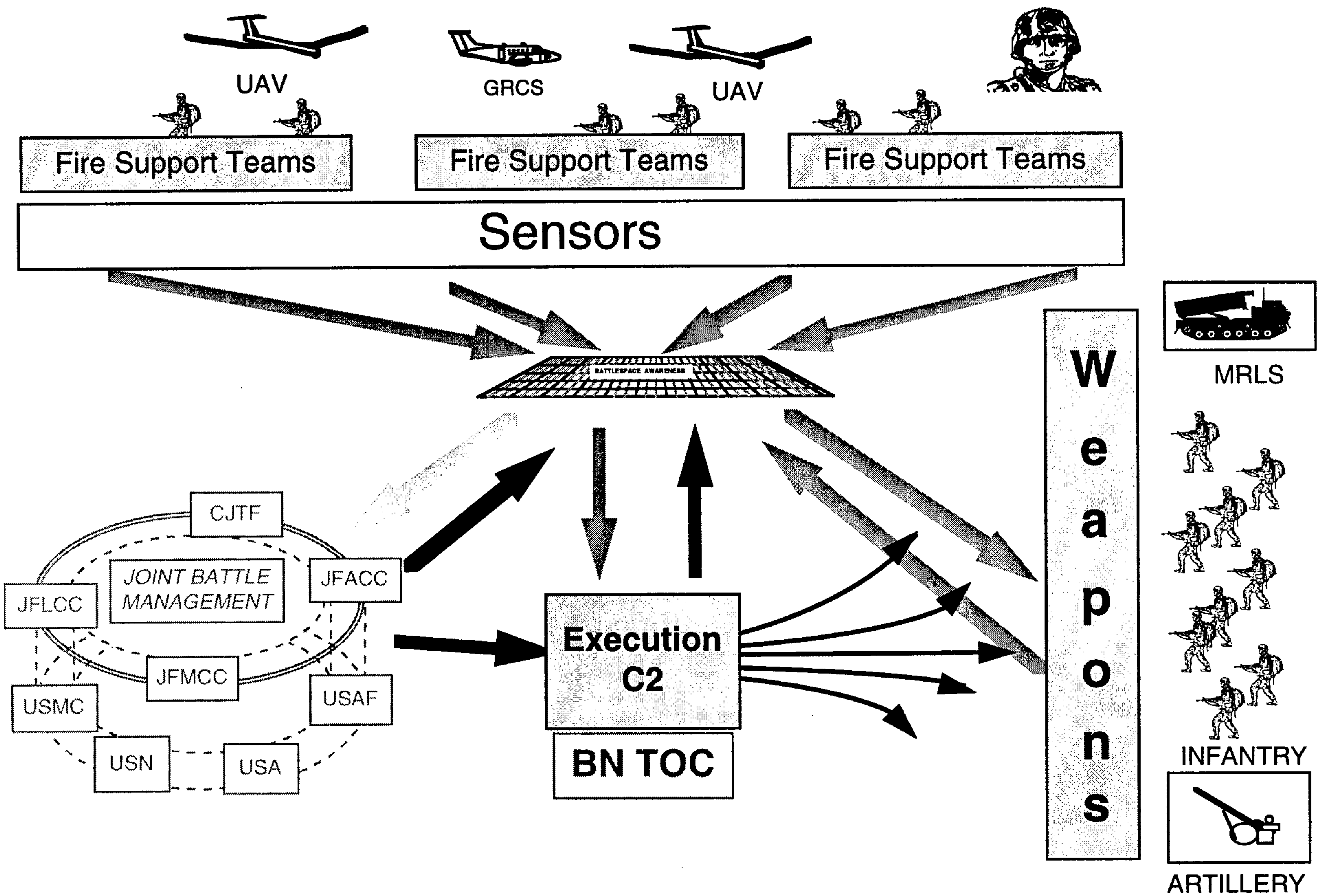
Information

Sensor-to-Shooter System Attributes

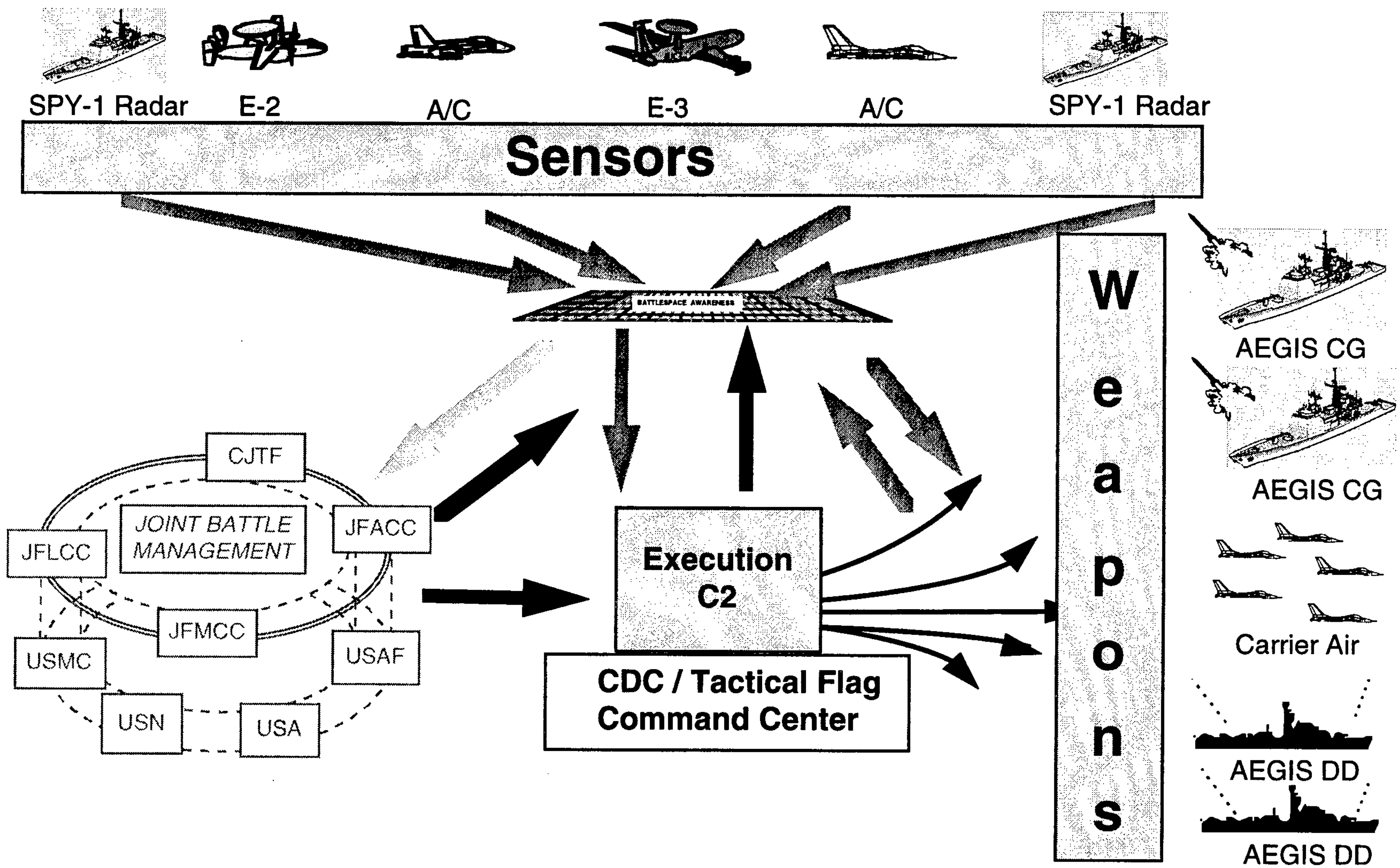
The key characteristics of the proposed sensor-to-shooter system concept are that they are parallel, fast, and dynamic, versus the current characterization as serial, slow, and nonresponsive. These capabilities will be enabled largely by key elements of the Grid concept, providing battlespace awareness, that is, simultaneous access to battlespace information by shooters and execution controllers as well as by battle managers. With the black arrows indicating command and the other arrows indicating information flow, the figure directs future operations as separate from the information flow from the command cycle. This is necessary to achieve the desired responsiveness. Furthermore, this characteristic is also a major driver in the need for dynamic planning capabilities and parallel operations.

In the proposed system concept, the sensors will continuously input new information into battlespace awareness databases while both executing elements (shooters and controllers) and battle managers will simultaneously be able to retrieve information. Much of the current conflict of competing sensor tasking will be resolved using integrated sensor management techniques. While the battle manager is seeking battlefield information throughout the entire battlespace, and when in common battlespaces, the shooters are seeking targeting information. This means that the shooter needs target location and identification, situation awareness in the target area, and clearance to shoot. Primarily, current shooters do not have adequate situation awareness in the target area. The connectivity and access achieved through implementation of the Grid will provide situational awareness, thus enabling shooters to execute the sensor-to-shooter operations successfully. The following three figures illustrate that current service operations can be envisioned in this context, although all of the desired capabilities are certainly not yet present.

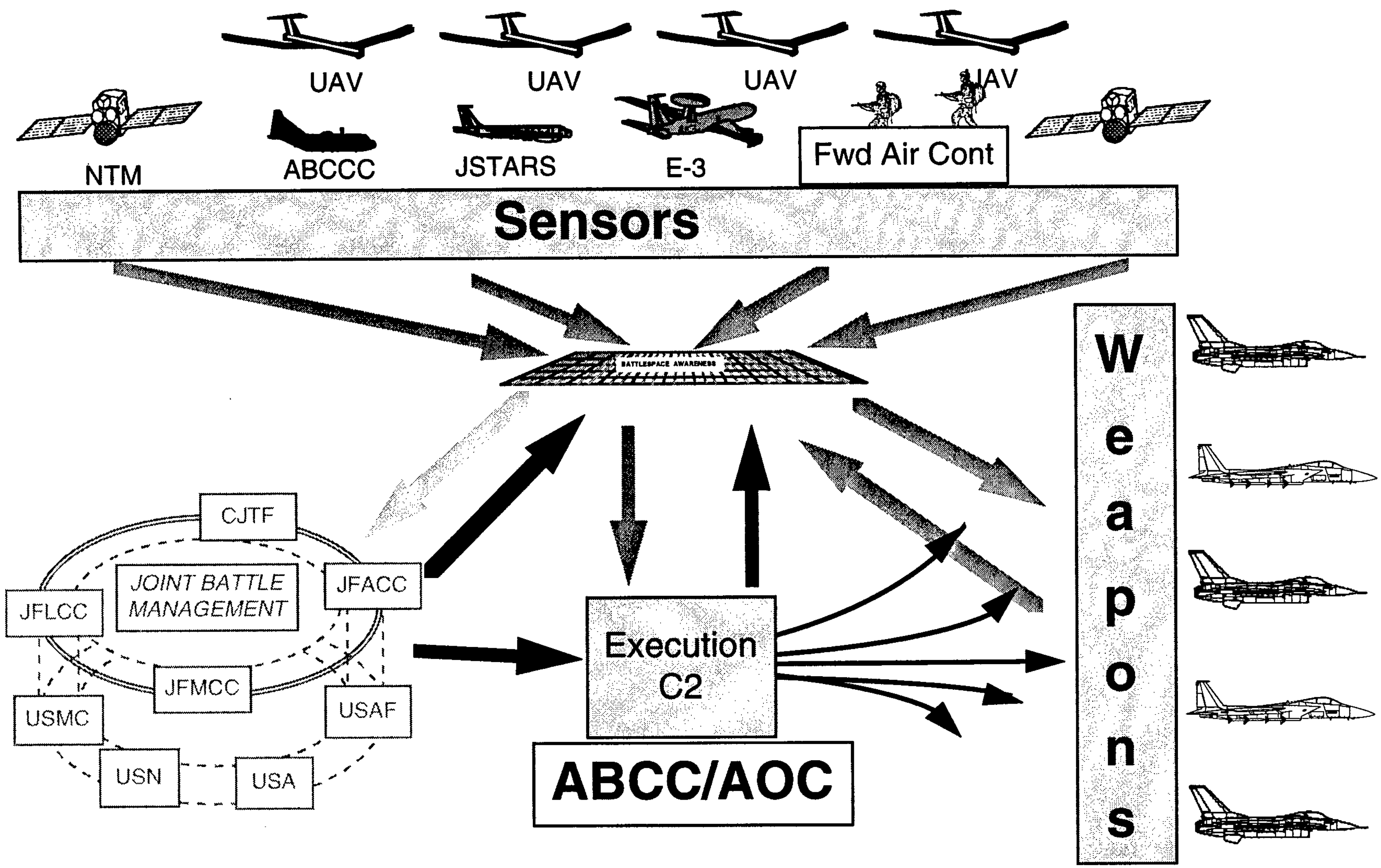
Army Call for Fire



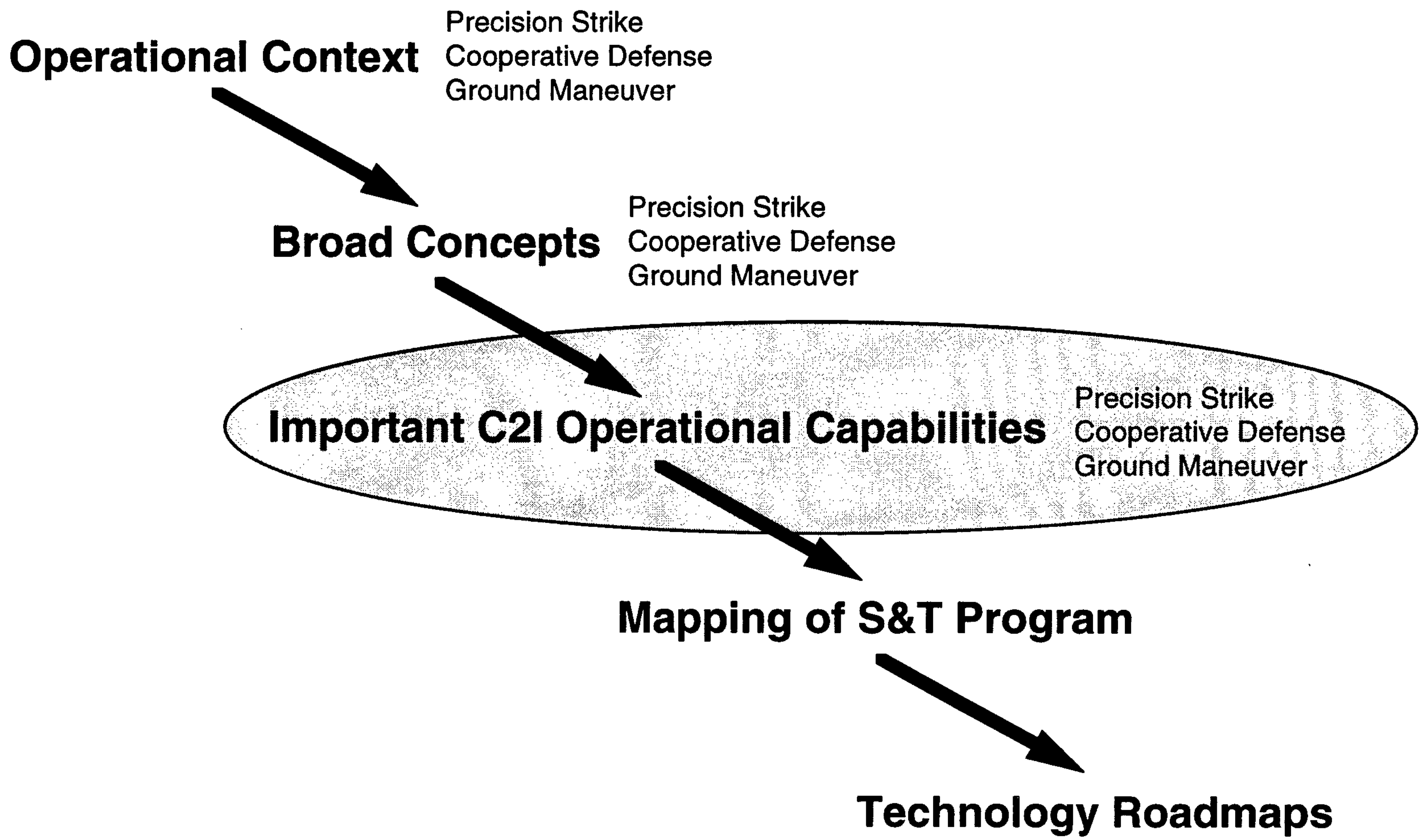
Naval Air Defense



Air Force Strike



Sensor-to-Shooter Working Group Approach



Important Operational Capabilities Are Characterized in These Combat Vignettes

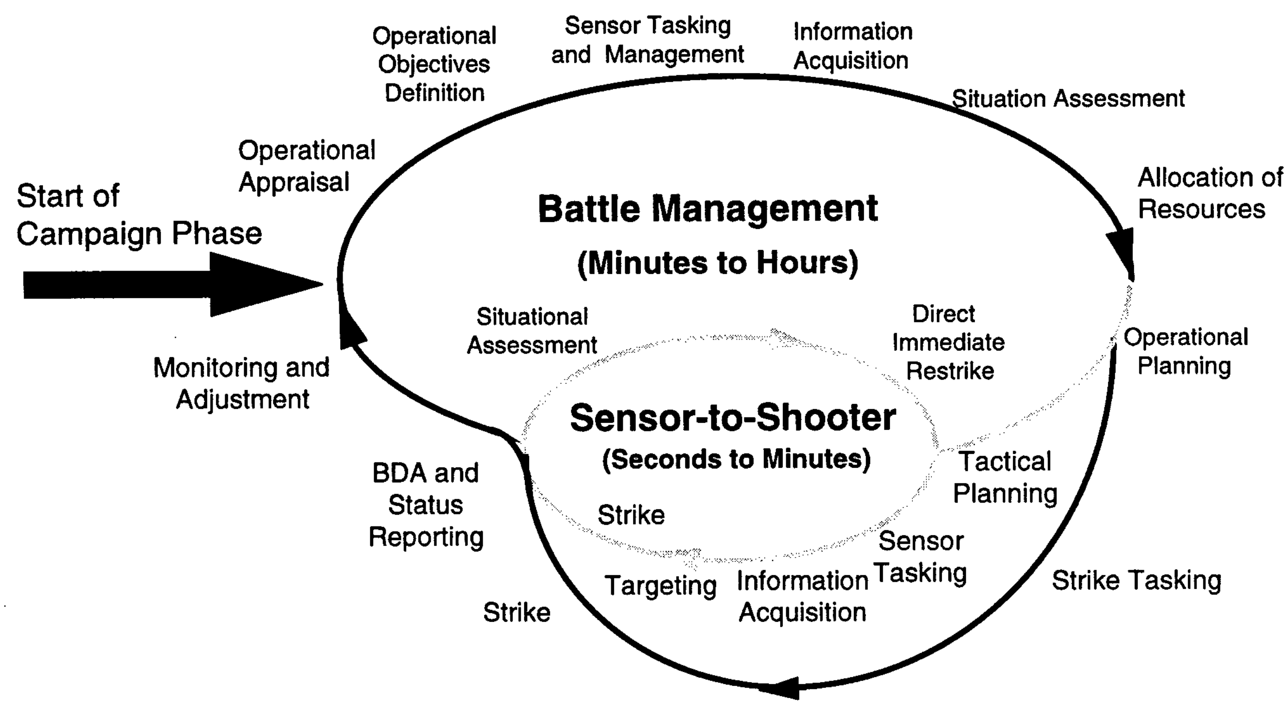
- Prosecution of Fleeting Targets
- Synchronized Execution of Preplanned ITO
- Prosecution of Maneuvering Targets
- Battle Damage Assessment
- Defensive or Offensive Counterair
- Dynamic, Deep Targets

Important Operational Capabilities Are Characterized in These Combat Vignettes

As illustrated in the two-loop model, sensor-to-shooter operations span timeframes typically characterized in terms of seconds, minutes, and tens of minutes. The working group used operational combat vignettes to access key relevant characteristics of these operations. The six vignettes presented here encompass most key aspects of sensor-to-shooter operations. Furthermore, each vignette is repeated many times in various types of conflicts—hundreds of times in major regional conflicts, and dozens of times in lesser regional conflicts. Only a few vignettes occur in operations other than war. Nevertheless, the operational capabilities required are relatively unchanging.

- **Prosecution of Fleeting Targets** presents one of the most challenging situations. These targets, such as Scud launchers and multiple rocket launchers, were not successfully prosecuted during the Gulf War, nor has the capability been demonstrated consistently since then. The challenge for sensor-to-shooter operations involves both timeliness of specific actions and effective coordination of assets.
- **Synchronized Execution of the Preplanned Integrated Tasking Order (ITO)** presents a different challenge. Current systems are serial, are oriented toward single service execution, and are slow (taking days) while fast, continuous and dynamic, true joint operations are desired.
- **Prosecution of Maneuvering Targets** is the primary vignette involving the individual soldier, both as shooter and as sensor.
- **Battle Damage Assessment** (BDA) improvements are a much-desired and long-awaited capability, but are not yet a reality of combat operations. Ideally, each shooter will also become a BDA sensor, providing inputs to the Battlespace Awareness Grid.
- **Defensive or Offensive Counterair** capabilities are segmented and isolated from other operations. True integrated capability with other combat operations will result in a substantial advantage to our forces.
- **Prosecution of Dynamic, Deep Targets,** such as a column of tanks, involves a different challenge than fleeting targets —easier detection and location, but emphasizing dynamic retargeting capabilities.

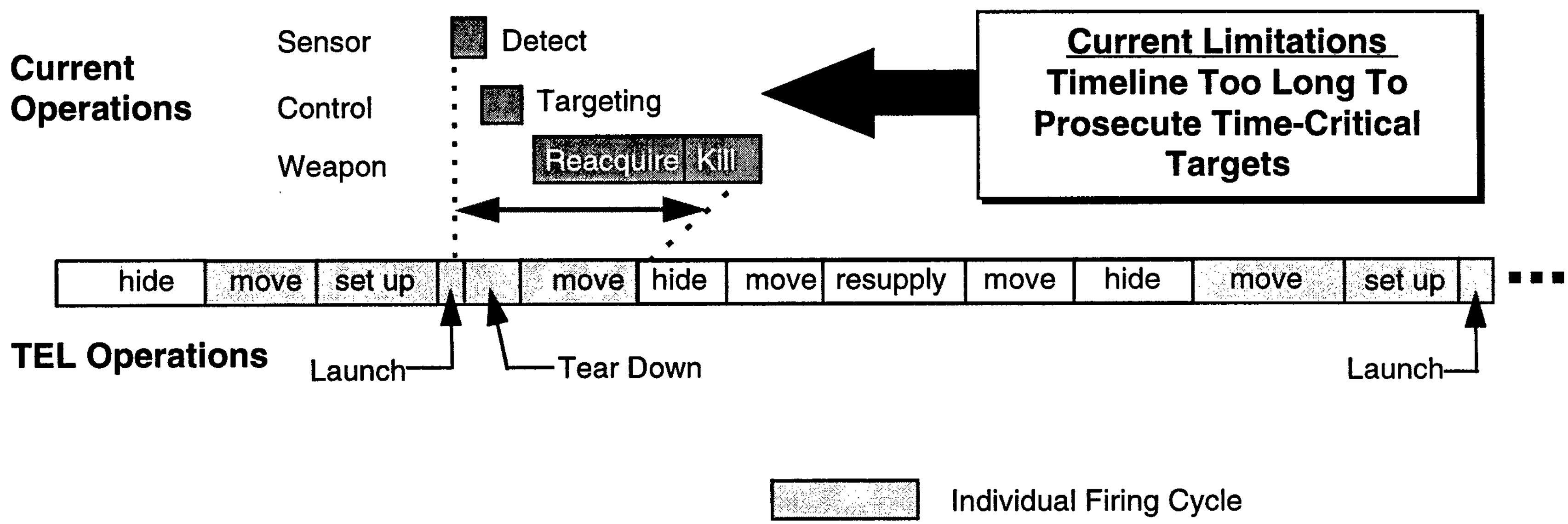
Prosecution of Fleeting Targets



Prosecution of Fleeting Targets

The first vignette is the most challenging operational situation. As depicted in the flow figure, this vignette involves the inner loop in the most time-critical fashion, with the extremely short target cycle times permitting only seconds to minutes for the entire sensor-to-shooter process from initial target detection through strike, BDA, and restrike if necessary.

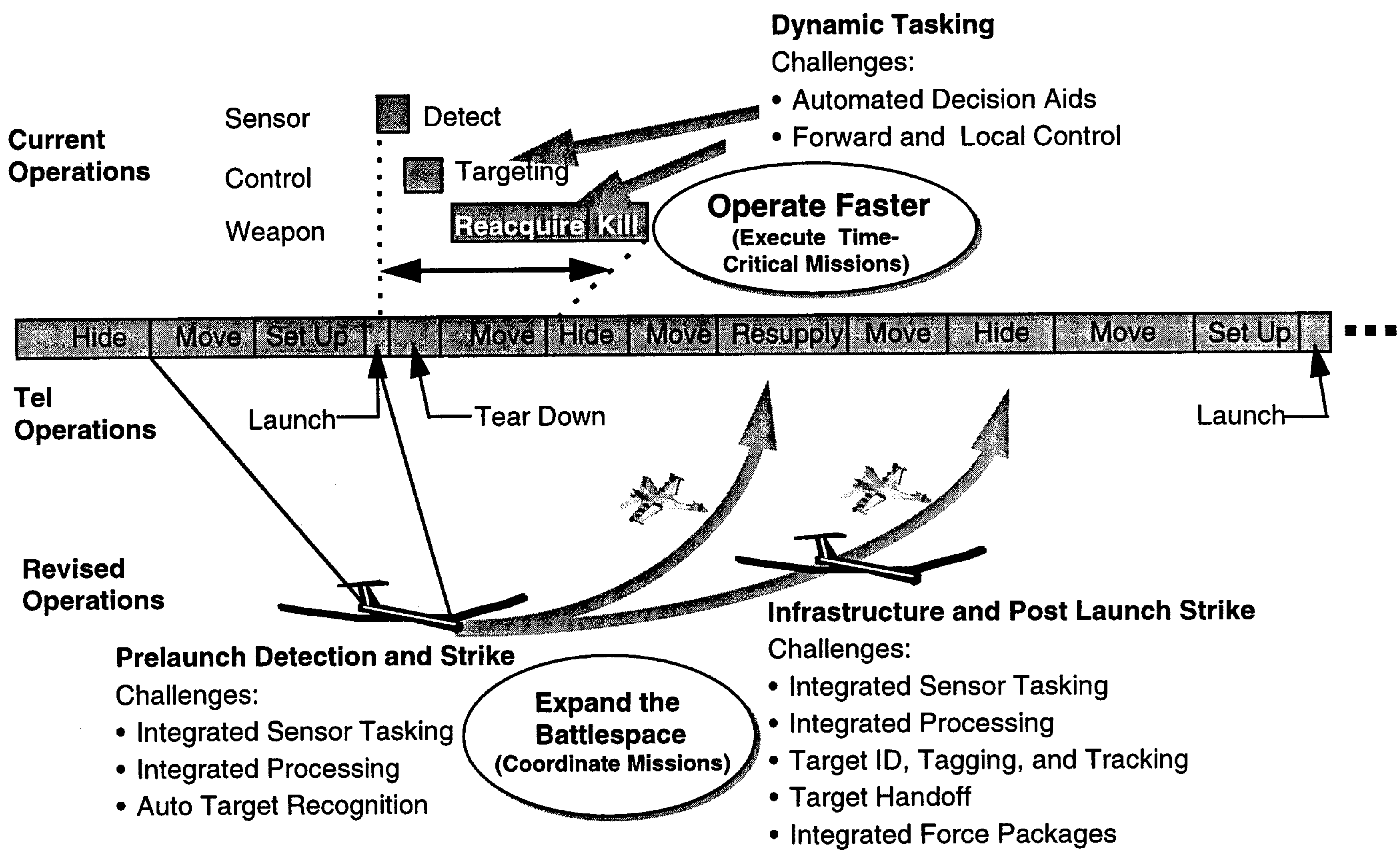
Prosecution of Fleeting Targets
Current Operations and Limitations



Prosecution of Fleeting Targets
Current Operations and Limitations

Assessing current operations against fleeting targets such as transportable erectable launchers (TEL) for tactical ballistic missiles reveals that the primary shortfall is the timelines are too long, meaning the time to detect the threat, assess the situation and decide to take action, respond to the tasking by a shooter, and hand off the information between the elements of the sensor-to-shooter. In all cases, the time to take the necessary actions is longer than the exposure of the target while executing a single firing cycle. The desired sensor-to-shooter operations under the future vision are illustrated in the next figure.

Prosecution of Fleeting Targets
Revised Operations and C4I Technology Challenges



Prosecution of Fleeting Targets
Revised Operations and C4I Technology Challenges

Under the proposed sensor-to-shooter operations of Vision 2010, two types of solutions will enable prosecution of fleeting targets:

1. To execute essentially the same functions as current operations, but to do so substantially faster, that is, to execute time-critical missions.

2. To expand the battlespace into pre- and post-launch TEL operations, that is, to coordinate missions.

In both cases, technology challenges must be overcome and a revised CONOPS must be developed. These advances in operational thinking and technologies must be developed simultaneously. Key challenges, stated primarily as functional areas of improvement or change, are noted in the figure.

Technology Packages

Common Technology Themes Across Mission Areas	
• Wideband Communications and Interconnectivity	A
• Real-Time, Cognition Aiding Displays	B
• Automated Planning/Decision Support Tools	C
• Data Interoperability/Synchronization	D
• Automated IPB Processes	E
• Fusion-Sensor Fusion as Well as Information Fusion	F
• Automatic Target Recognition and Acquisition	G
• Integrated Target Tracking	H
• Multilevel Security	J
• Dynamic ISR Resource Management	K

Technology Packages
Common Technology Themes Across Mission Areas

In each of the six combat vignettes, the Working Group first identified the **Current Limitations**, then defined the **Causes** for those limitations, then identified the **Critical Functional Capabilities** required to overcome these causes, and finally determined the **Technology Challenges** that must be solved to provide the Critical Functional Capabilities. Although there were also doctrinal, acquisition, operational, and other issues that had to be addressed, the working group's charter was limited to identifying the technology challenges; therefore, these nontechnological issues were left largely unaddressed. The technology challenges were then grouped into the 10 technology areas listed here. The working group related each of these technology areas to the combat vignettes in which the important C2I operational capabilities were characterized. This was a critical step because many of the technologies are well developed, but are not oriented toward shooter timeframes and areas of interest.

Operations—Technology Crosswalk
Prosecution of Fleeting Targets

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Long	• Slow Decision and Resource Allocation Process With Respect To Target Cycle Times	• Highly Responsive (Less Than a Minute) Ability To Match Target With Constrained Resource Package	• Preplanned and Dynamic Responses	C
			• Preplanned and Dynamic Prioritization	C
			• Automated Target Weapon Pairing	C
			• QRC Decision Aids	C
		• Rapid, Continuous IPB With Joint Processing and Dissemination	• Joint Fusion	F
		• Detect and Classify Targets In Fraction of Cycle Time	• Automatic Target Recognition For Fleeting Target Behaviors	G

Operations—Technology Crosswalk
Prosecution of Fleeting Targets

The Operations–Technology Crosswalks used for assessment purposes by the working group are illustrated in this figure and the following two figures for the fleeting target vignette. The working group first identified the **Current Limitations** inherent in executing the operations depicted in the vignette, then defined the **Causes** for those limitations, then identified the **Critical Functional Capabilities** required to overcome these causes, and finally, determined the **Technology Challenges** that must be solved to provide the Critical Functional Capabilities. Because the working group's charter was to identify the technology challenges, nontechnological issues, such as doctrinal, acquisition, and operational, were largely not addressed. The letter references along the right-hand margin of the facing figure provide a cross reference from the specific technology challenges identified for each of the vignettes to the 10 technology areas identified by the working group and summarized at the beginning of this section.

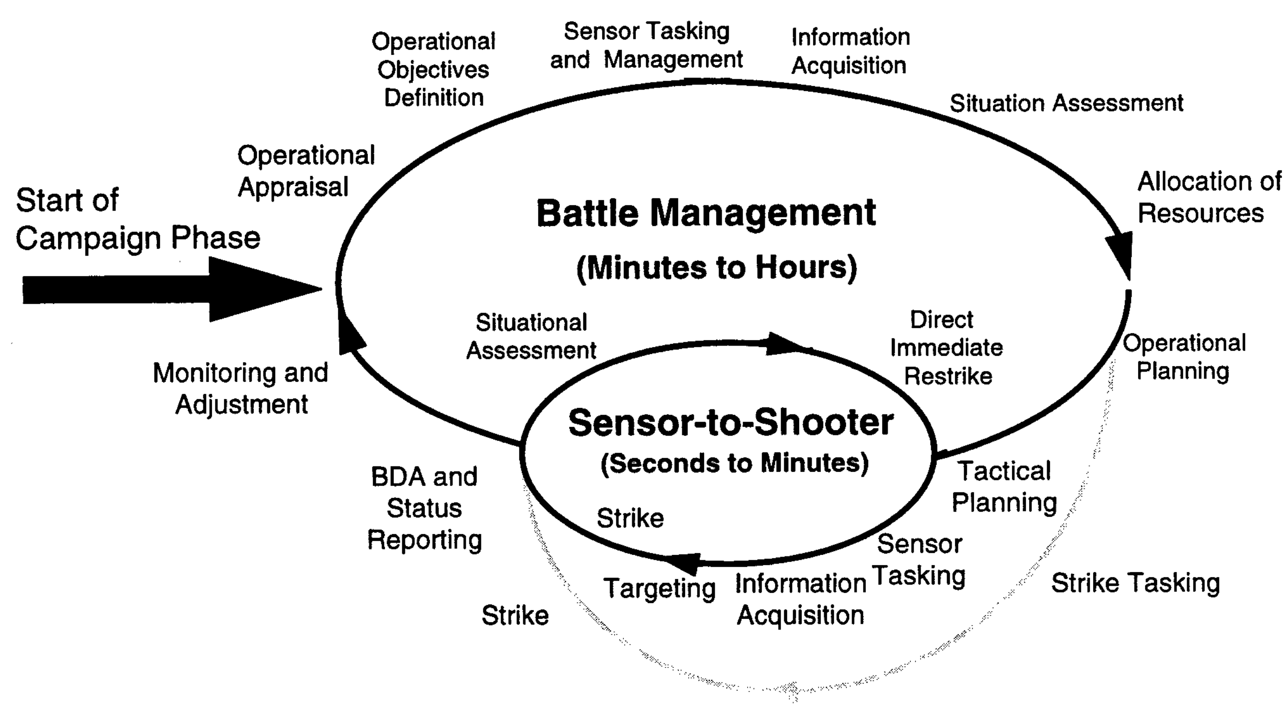
Operations–Technology Crosswalk
Prosecution of Fleeting Targets *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Slow	• Poor Detection of Fleeting Target Entities In Crowded Battlespace	• Integrated Tasking and Processing of Sensors (Tactical, Theater, National) and Weapons for Prelaunch and Multicycle Detection and Prosecution	• Sensor Cross Cueing	**K**
			• Data Validity Tags	**F**
			• Automated Data Validation	**F**
			• Tactical Tasking Of Sensors	**K**
			• Integrated, Dynamic Sensor and Weapon Tasking	**C&K**
			• Integration of Non-Conventional and Cross Mission Sensors	**K**
			• Target Infrastructure ID	**E,F&G**
			• Continuous Target Tracking (Cross-Sensor)	**H&K**

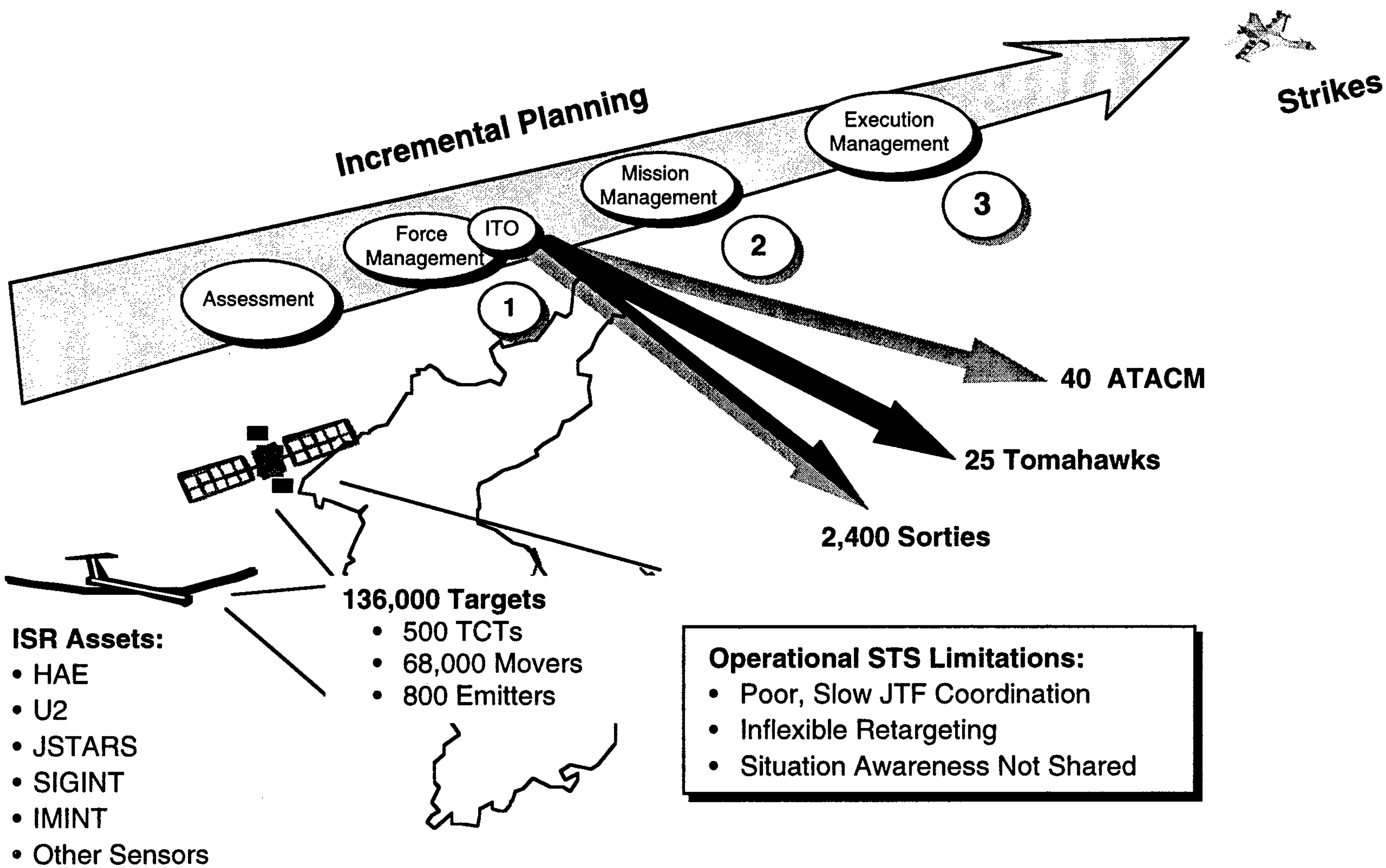
Operations–Technology Crosswalk
Prosecution of Fleeting Targets *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Long	• Slow Fusion Process	• Provision of Targeting Information in Real Time	• Transmit Track Quality Data Directly to Weapon and Weapons Platform	A
			• Positive ID—Hostiles	G
	• Best Sensor Information Not Incorporated	• Integrated Processing Across Sensor and Other Information Sources	• Sensor Fusion Across Spectrum and ISR Disciplines (i.e., SIGINT, ELINT, IMINT, MASINT)	F
			• Data Fusion To Incorporate Other Information	F

Synchronized Execution of Preplanned ITO

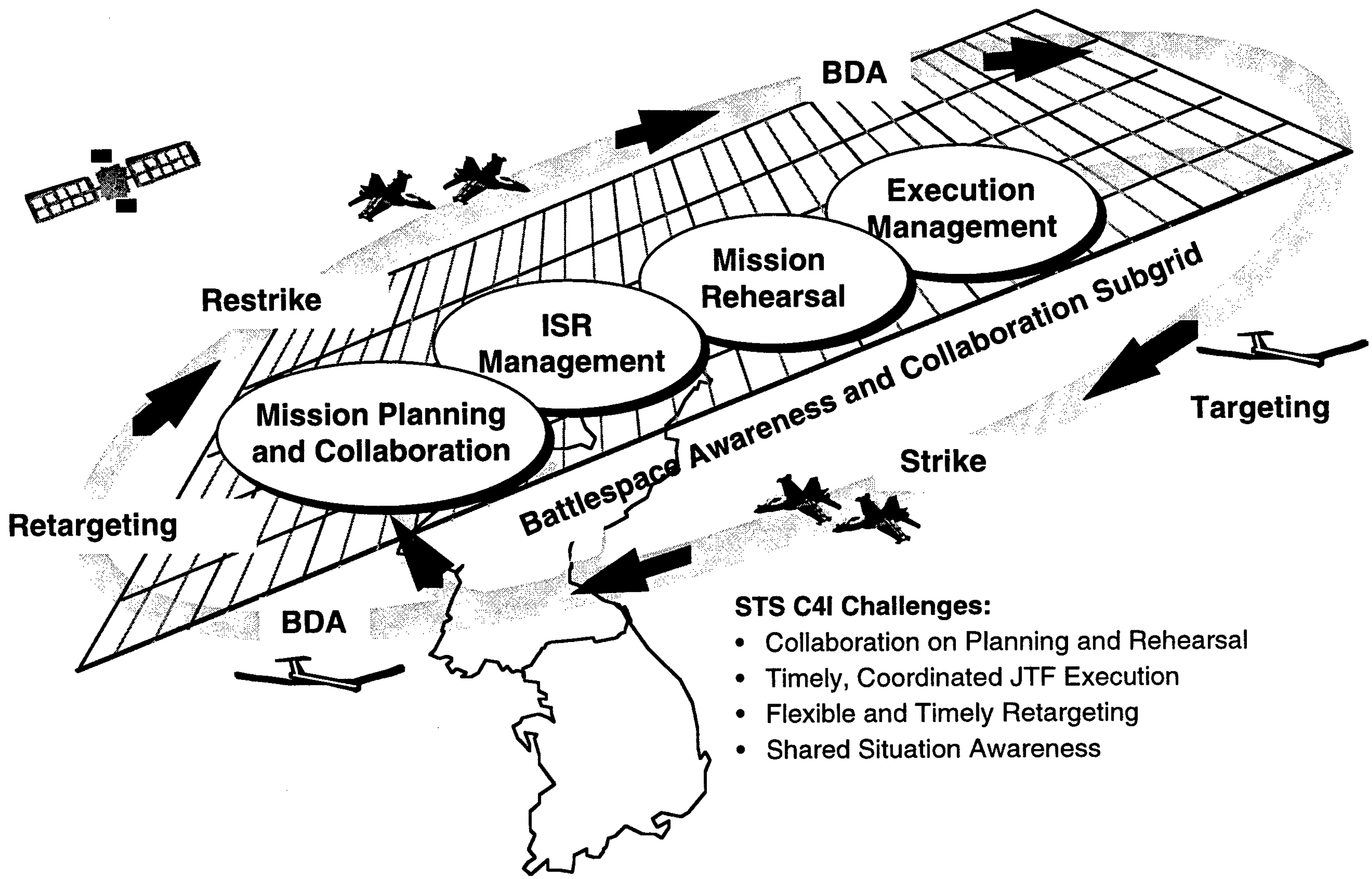


Synchronized Execution of Preplanned ITO Current Operations and STS Limitations



Operational STS Limitations:
- Poor, Slow JTF Coordination
- Inflexible Retargeting
- Situation Awareness Not Shared

Synchronized Execution of Preplanned ITO Revised Operations and C4I Challenges



STS C4I Challenges:
- Collaboration on Planning and Rehearsal
- Timely, Coordinated JTF Execution
- Flexible and Timely Retargeting
- Shared Situation Awareness

Operations–Technology Crosswalk Synchronized Execution of Preplanned ITO

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Inflexible Retargeting Against Dynamic Targets	• Targets Appear After Force Package Commitment: – Pop-up Targets – Movement Cycles	• Maintaining Continuous Awareness of Target Activity by Shooter Elements	• Unique Target ID Across Sensors	**H**
			• Real-Time Target Location Updates	**H**
		• Implement Air–Ground <u>Decide-Detect-Deliver</u> CONOPS and Real-Time Target Acquisition C2 Structure	• Continuous Observation of Target After Detection	**H&K**
			• Timely Loading of Target Information Into Weapon	**A**
	• Execution Status Unknown	• Provide Real-Time Status Information on Force Elements (i.e., by Tail Number)		**A,B,&C**

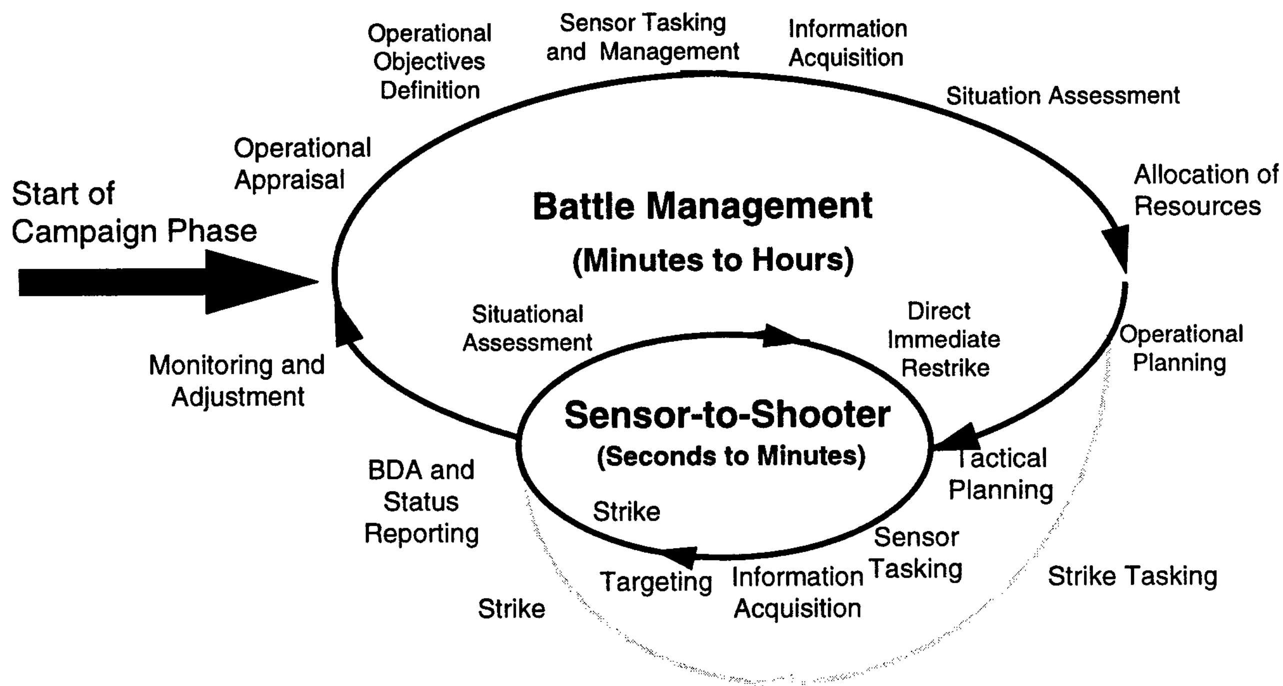
Operations–Technology Crosswalk
Synchronized Execution of Preplanned ITO *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Inflexible Retargeting Against Dynamic Targets	• Inability for Timely Counteraction to Target Reaction	• Real-Time Force Package and Weapon Retasking as Target Status Changes (Within Inventory Constraints)	• Real-Time Update of Target-Weapon Pairing To Achieve Strategic Objectives	**C&D**
	• Inadequate Coordination for Timely Response	• Enable Real-Time, On-line Coordination Between Elements of Force Package (i.e., Shooter-to-Controller, Ground Shooter-to-Air Shooter)	• Providing Sufficient Video-Voice-Graphics Capability Without Distracting Shooters	**A&B**

Operations–Technology Crosswalk
Synchronized Execution of Preplanned ITO *(Continued)*

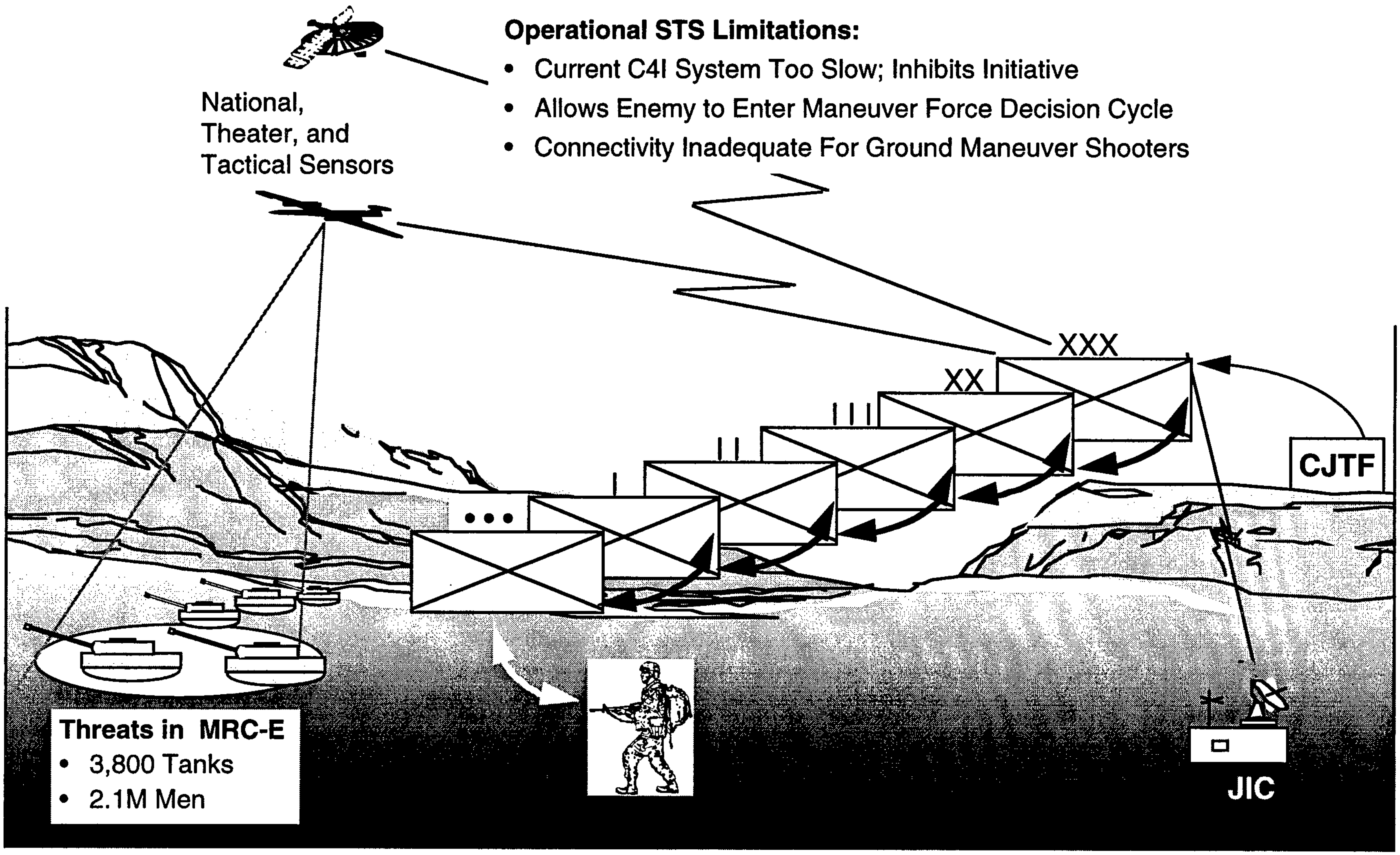
Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Situational Awareness Not Shared: – Across Missions – Across Services – Between Allies – Between BM and Shooters	• BM Reluctant To Release	• Timely Release of Best Available Information Indicating Expected Updates	• Providing Joint Commanders Intention and Guidance On-line in NRT	**A,B,&D**
	• Different Information Needs for Different Users	• Tailoring Common Picture to Individual Needs of Multiple Users	• Fusion on INT Data for OB Track History	**F**
		• Integration of Data From All Sensors (i.e., Active Defense, Recce)	• Development of Common Ground-Air-Naval Picture and Symbology	**B,D,&F**
			• NRT Mission/User-Based Extraction	**B&D**
	• Simultaneous Pulls on Sensors	• Enable Targeting Data to Shooters and SA Data to BMgrs		**C&K**
	• Insufficient Connectivity	• Sufficient Bandwidth, Links, and Trust To Enable Coalition Connectivity To Ground Shooter	• Mission Security	**K**
			• Standards for Links, Protocols, etc.	**D**
			• Links for Ground Shooters	

Prosecution of Maneuvering Targets

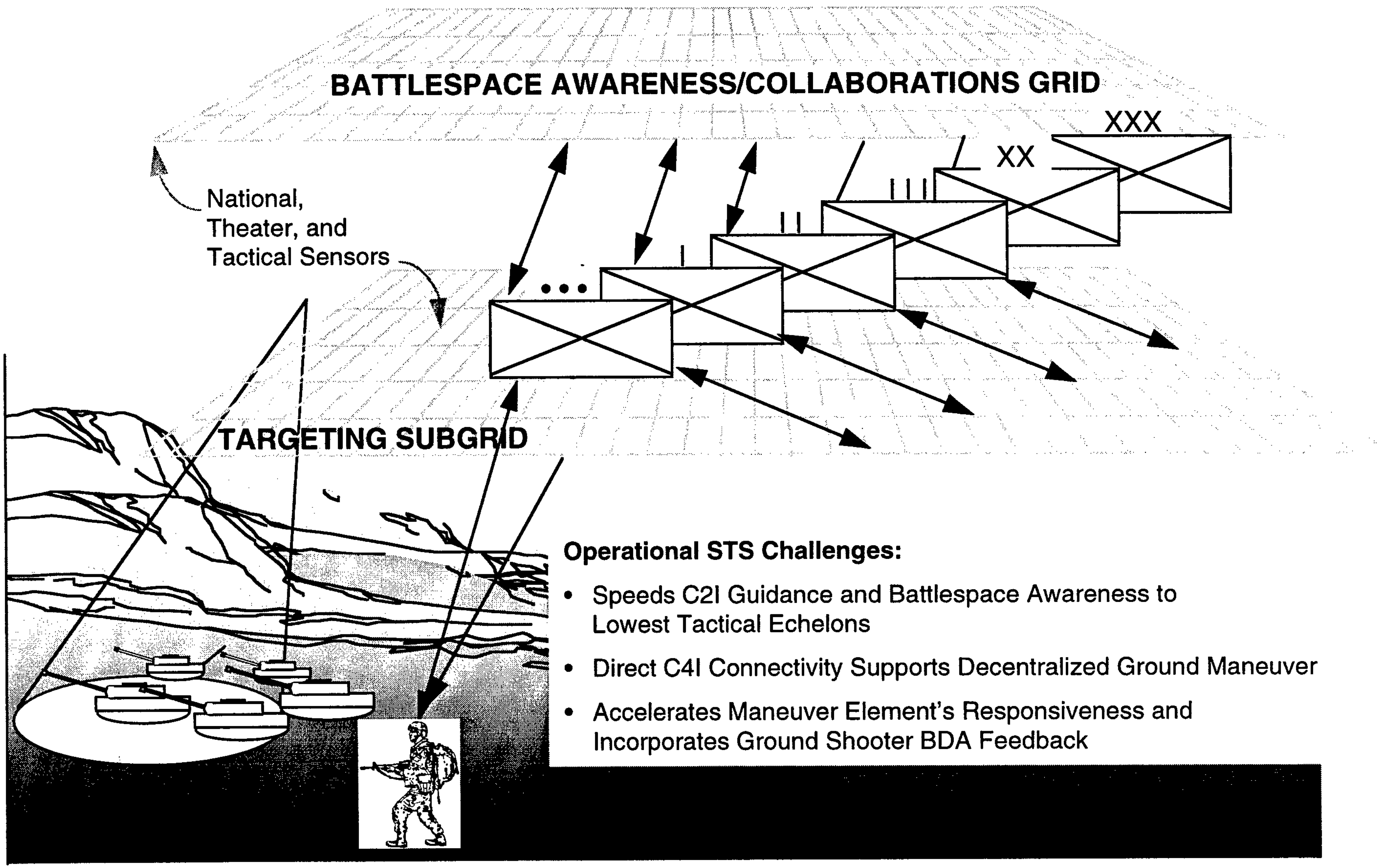


Prosecution of Maneuvering Targets
Current Operations and STS Limitations

Operational STS Limitations:
- Current C4I System Too Slow; Inhibits Initiative
- Allows Enemy to Enter Maneuver Force Decision Cycle
- Connectivity Inadequate For Ground Maneuver Shooters



Prosecution of Maneuvering Targets Revised Operations and C4I Challenges



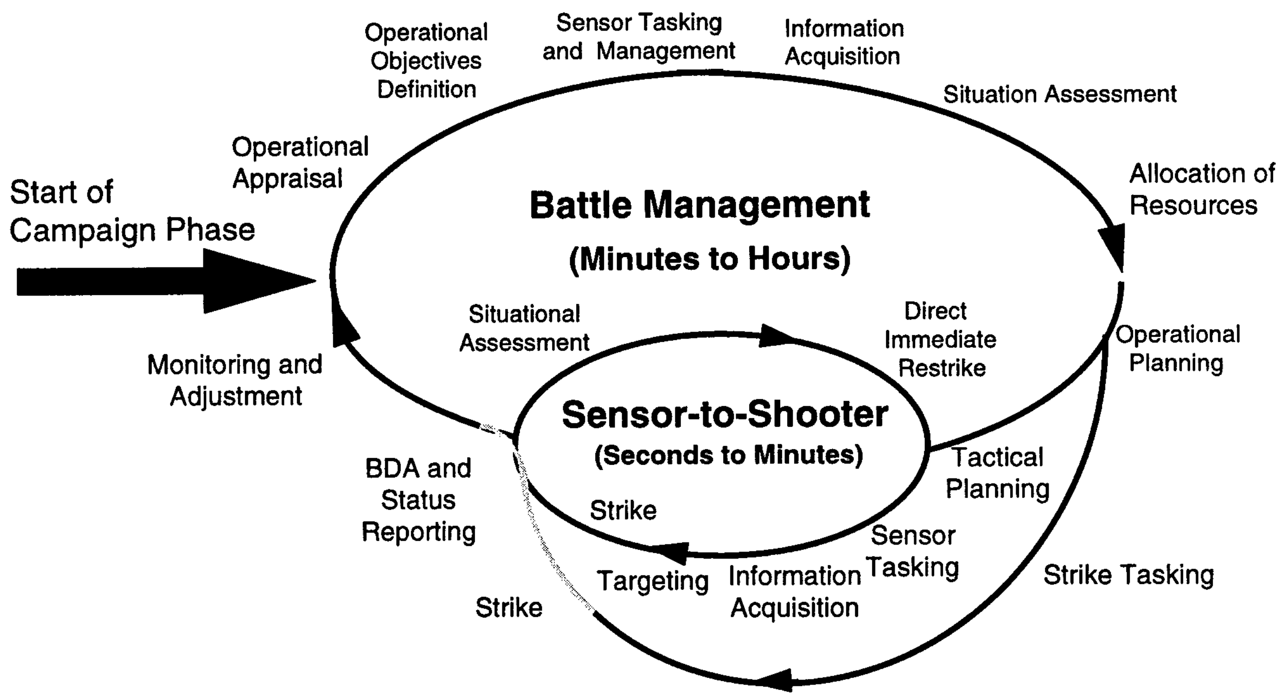
Operational STS Challenges:

- Speeds C2I Guidance and Battlespace Awareness to Lowest Tactical Echelons
- Direct C4I Connectivity Supports Decentralized Ground Maneuver
- Accelerates Maneuver Element's Responsiveness and Incorporates Ground Shooter BDA Feedback

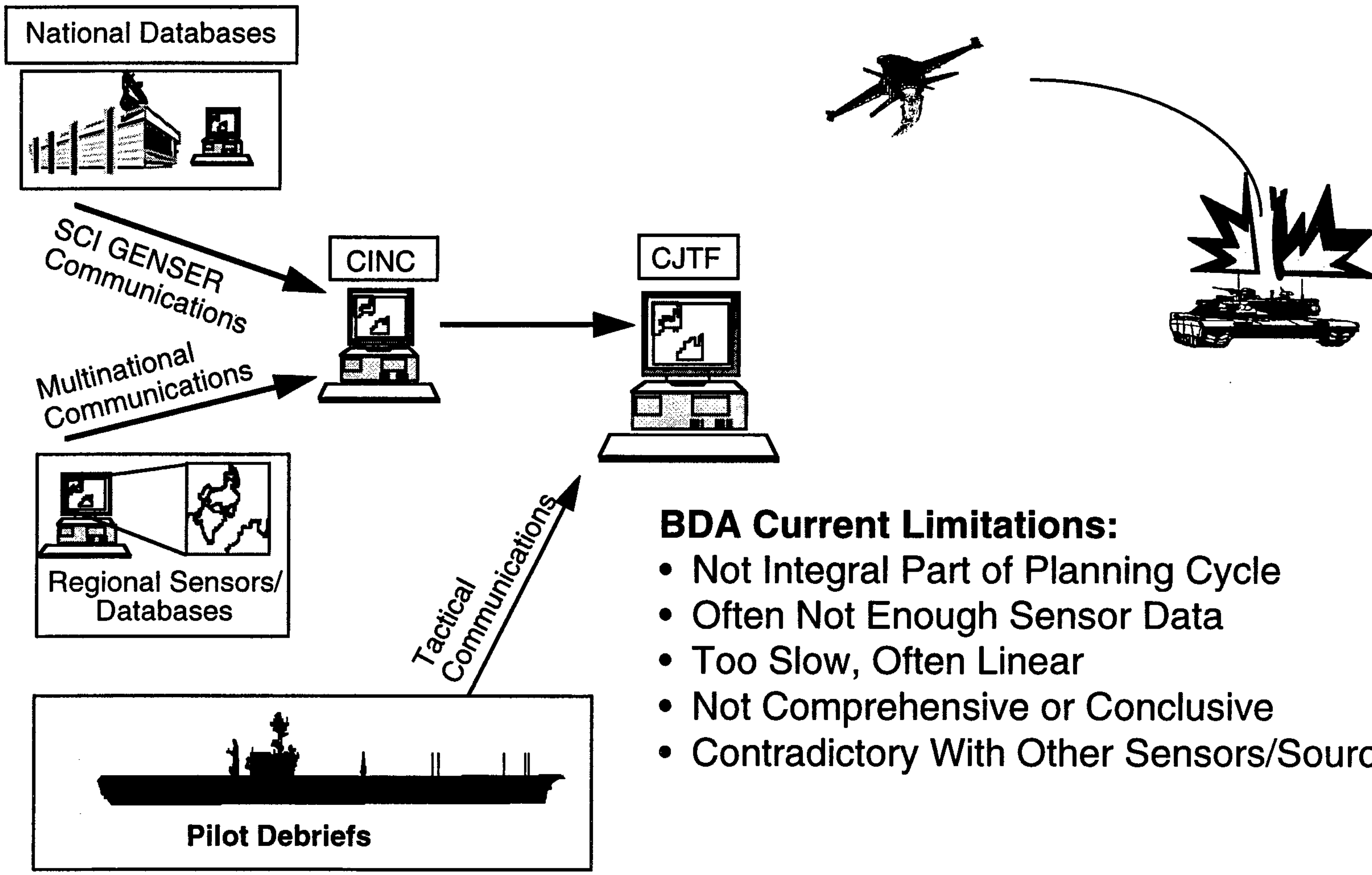
Operations–Technology Crosswalk
Prosecution of Maneuvering Targets

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Long	• Slow Communications and Information Processing Capability at Command Echelons	• Highly Responsive Ability for Ground Shooter To Pull and Receive Highly Perishable STS Information	• Tactical Man-Portable C4I Systems • BA and C2I Direct Connectivity	A,B,&K A&K
• STS Information Passes Through Too Many Command Echelons	• Lack of Command by Negation	• Ability for User To Directly Receive Fused Intel and C2 Information	• Transmit Track Quality Data Directly to Weapon and Weapons Platform	C,G,J,&K
• No Timely Ground Shooter BDA	• Insufficient Connectivity	• Sufficient Links and Bandwidth to Lowest Level of Tactical Shooter	• Positive ID-Hostiles	C,G,J,&K

Battle Damage Assessment

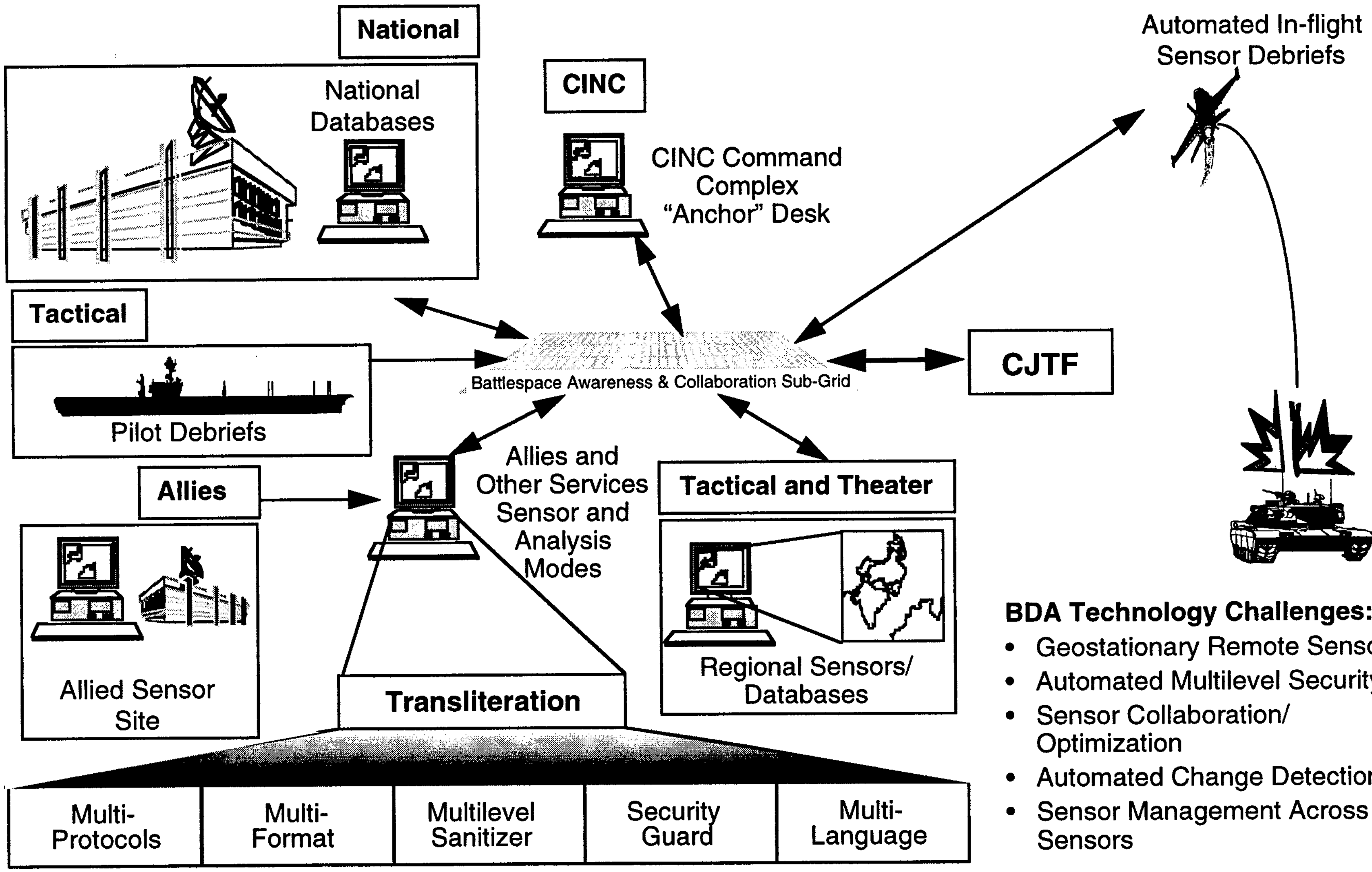


Battle Damage Assessment
Current Operations and Limitations



BDA Current Limitations:
- Not Integral Part of Planning Cycle
- Often Not Enough Sensor Data
- Too Slow, Often Linear
- Not Comprehensive or Conclusive
- Contradictory With Other Sensors/Sources

Battle Damage Assessment
Revised Operations and C4I Technology Challenges



BDA Technology Challenges:
- Geostationary Remote Sensors
- Automated Multilevel Security
- Sensor Collaboration/ Optimization
- Automated Change Detection
- Sensor Management Across Sensors

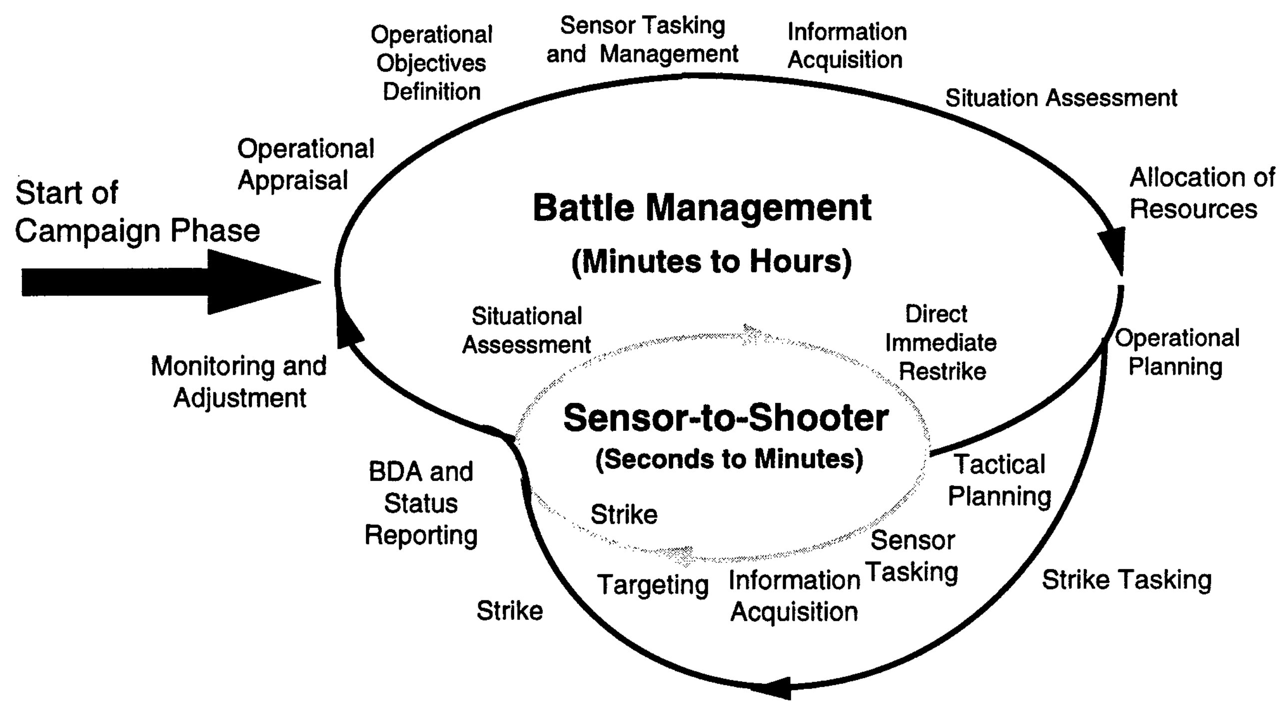
Operations–Technology Crosswalk
Battle Damage Assessment

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• BDA Not Matched to Optempo	• Lack of Sensors	• Integrate Tactical Sensors	• Connectivity	A&K
			• Bandwidth	
		• Integrate Allied Sensors	• Automated Multilevel Security	J
		• Long Dwell Sensors	• High Revisit Rate	K
			• Geostationary Sensors	
	• Man-Intensive BDA Analysis	• Automate Processes	• Automated Change Detection	G
		• Sensors Integrated Into Operational Objectives	• Automate Sensor Optimization Across Joint Objectives	C&K
	• Sensor Management Not Tied Directly to Commander's Intentions		• Multilevel Security	J
			• Sensor Management Across All Sensor Types	C&K

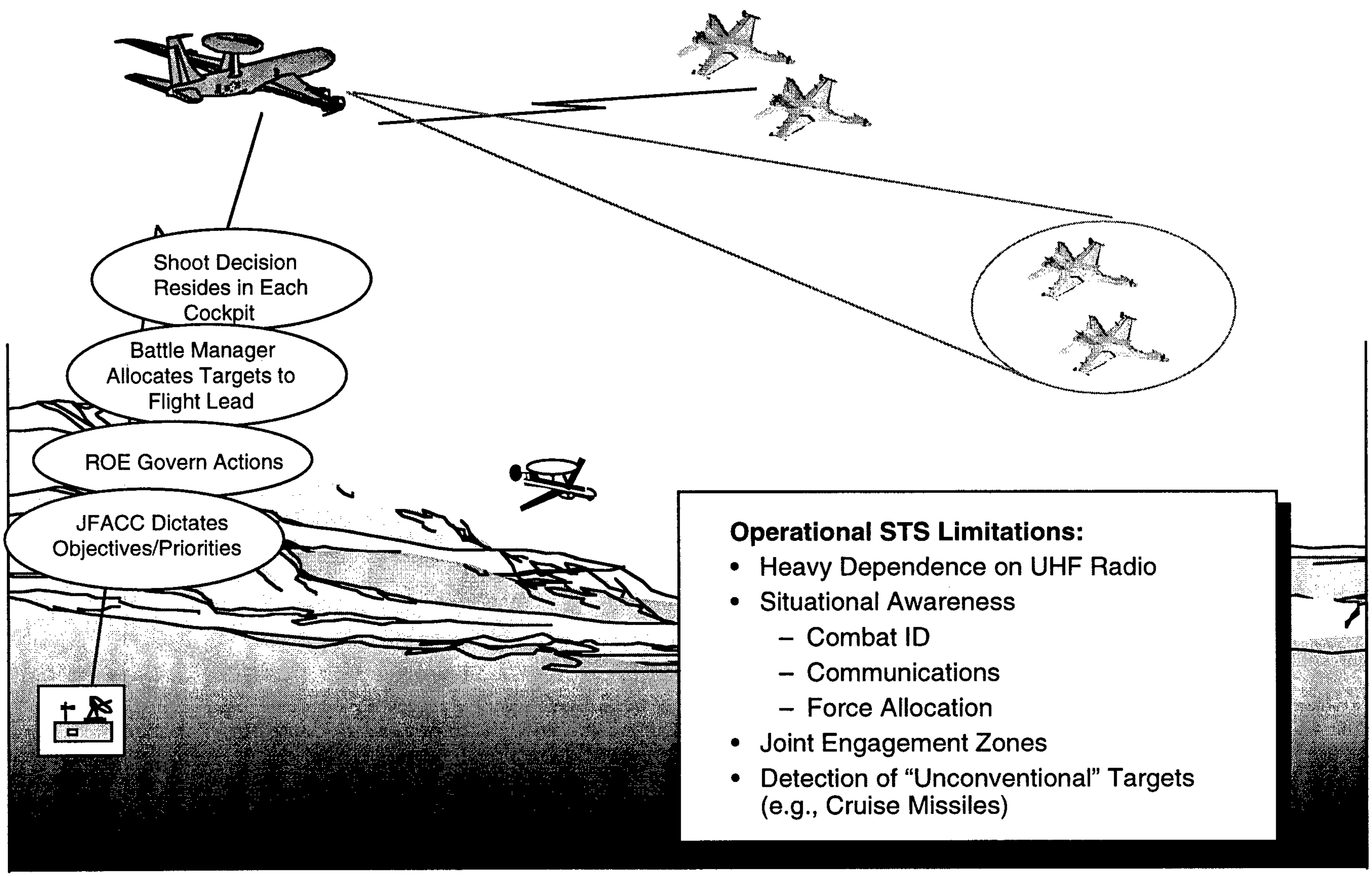
Operations–Technology Crosswalk
Battle Damage Assessment

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• BDA Not Matched to Optempo	• Lack of Sensors	• Integrate Tactical Sensors From All Mission Areas (Including Individual Soldier)	• Connectivity • Bandwidth • Sensor Target Matching	A&K
		• Integrate Allied Sensors	• Automated Multilevel Security	J
		• Long Dwell Sensors	• High Revisit Rate • Geostationary Sensors	K
	• Man-Intensive BDA Analysis	• Automate Processes	• Automated Change Detection	G
	• Sensor Management Not Tied Directly to Commander's Intentions	• Sensors Integrated Into Operational Objectives	• Automate Sensor Optimization Across Joint Objectives	C&K
			• Multilevel Security	J
			• Sensor Management Across All Sensor Types	C&K

Defensive or Offensive Counterair

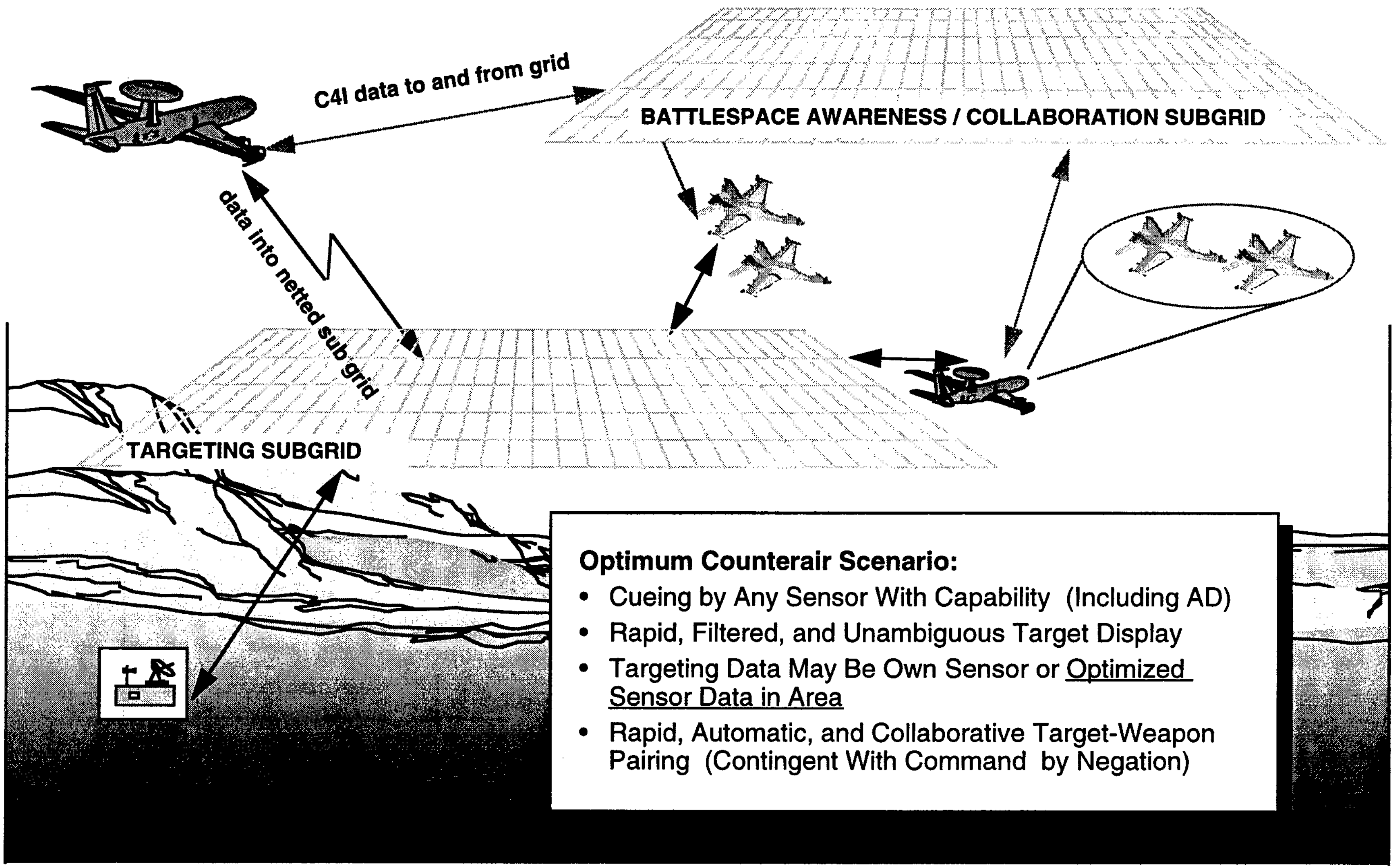


Defensive or Offensive Counterair Current Operations and STS Limitations



Operational STS Limitations:
- Heavy Dependence on UHF Radio
- Situational Awareness
  - Combat ID
  - Communications
  - Force Allocation
- Joint Engagement Zones
- Detection of "Unconventional" Targets (e.g., Cruise Missiles)

Defensive or Offensive Counterair Revised Operations and C4I Technology Challenges



Optimum Counterair Scenario:

- Cueing by Any Sensor With Capability (Including AD)
- Rapid, Filtered, and Unambiguous Target Display
- Targeting Data May Be Own Sensor or <u>Optimized Sensor Data in Area</u>
- Rapid, Automatic, and Collaborative Target-Weapon Pairing (Contingent With Command by Negation)

Operations–Technology Crosswalk Counterair Operations

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Nonintegrated Air and Ground Defense (Joint Engagement Zones)	• Inability To Communicate Adequately Between Defensive Systems	• Mutual Support Between Ground and Air Defense Systems	• Interactive Ground/Air Situational Awareness	A,B,&F
			• Interactive Ground/Air Tracking and Weapons Status	A,B,D,&H
			• Dynamic Translation of Legacy Systems Data Into Standardized Data Formats	D&H
	• Inability To Maintain Positive Hostile ID in Dynamic Battle	• Maintain Track ID on Contacts in Maneuvering Flight	• Interactive Ground/Air Tracking of Counterair Contacts With Designated Area	A,B,&F

Operations–Technology Crosswalk Counterair Operations *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Nonintegrated Air and Ground Defense (Joint Engagement Zones)	• Force Allocation Is Time Consuming	• Adequate Information for Battle Management/ Execution	• Development of Common Ground-Air-Naval Picture and Symbology	**A,B,&D**
			• Automated, Dynamically Updated Target Prioritization Against Commander's Objectives	**C&D**
	• Force Allocation Is Not Optimized	• Adequate Information for Battle Execution Target-Weapons Allocation	• Automated, Dynamically Updated Weapons Availability	**D&F**
			• Automated, Optimization of Weapons-Target Pairings	**C&K**

Operations–Technology Crosswalk Counterair Operations *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Situational Awareness Does Not Permit Rapid Decision-Making	• Inadequate Information Available to Shooter	• Integrated Sensors That Provide Real-Time Information to Shooters Tailored to Their Needs	• Sensors, Processing, and Links Capable of Providing Information in Suitable Formats in a Real-Time Environment	**A,D,F,&H**
	• Inadequate Ability To Display Information	• Easily Interpreted SA Displays With Continuous Real-Time Updates	• 3D Display (From Above) Showing Local Airborne Objects CID and Track Information	**A,B,&H**
			• Data Fusion To Incorporate Other Information	**A&F**

Operations–Technology Crosswalk Counterair Operations *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Situational Awareness Does Not Permit Rapid Decision-Making	• Information Saturation, Misinterpretation	• Unambiguous Information Transmission, Filtered and Tailored, Easily Displayed and Interpreted	• Positive ID-Hostile Target	**A**
			• Data Validity Tags	**F**
			• Data Validation, Done Automatically	**G**
			• Dynamic Fusion/ Filtering	**F**
	• Inadequate Information About Status of Threat and Friendly Assets	• Capability To Know the Combat Potential of Both Friendly Assets and Enemy Targets	• Target Status and Infrastructure ID	**E,F,&G**
			• Automate Sensor Optimization Across Joint Objectives	**C&K**

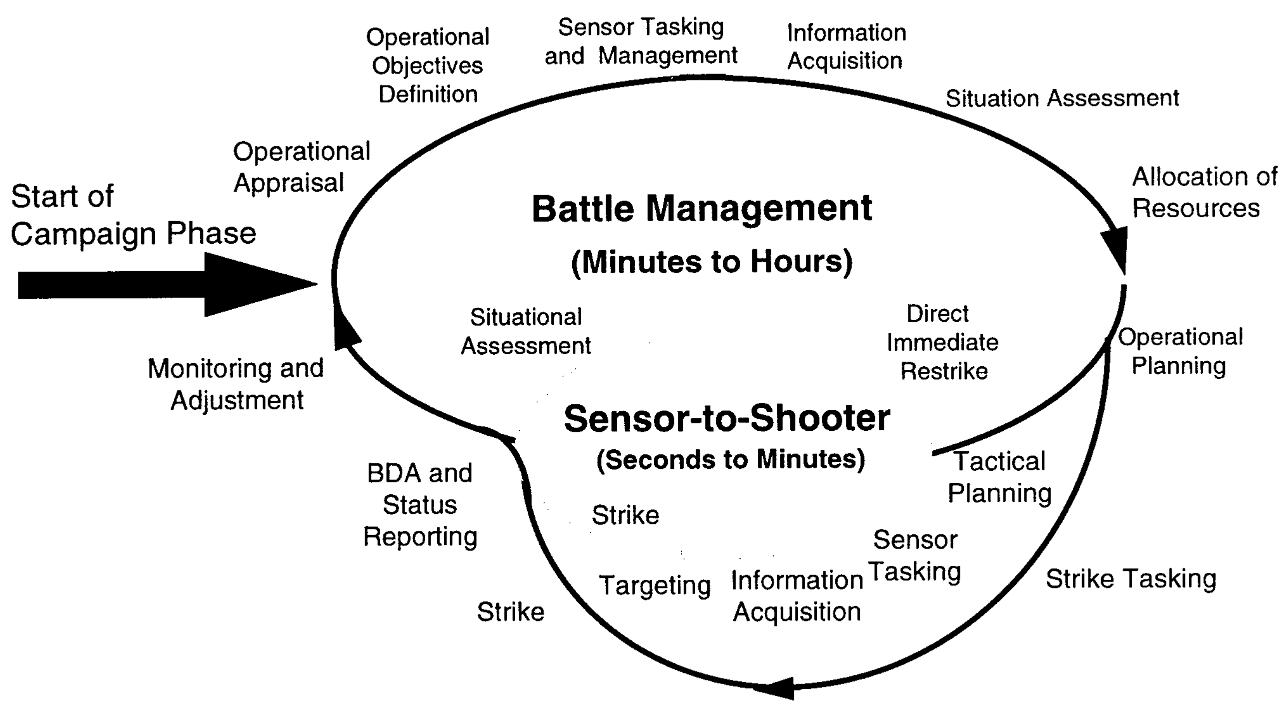
Operations–Technology Crosswalk Counterair Operations *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Situational Awareness Does Not Permit Rapid Decision-Making	• Unable To Assure Airspace Deconfliction	• Confident Application of Long-Range Systems in a Dynamic Environment	• Sensor Grid, Processing, and Links/ Grids Capable of Providing Information in Suitable Formats in a Dynamic Environment	**A,D,F,&H**
	• Proliferation of "Gray" Threat	• Ability To Distinguish Friendly Aircraft, Even When Similar Type Flown by Adversary (Without Reliance on Interactive Systems)	• Combat ID	**E&F**
			• Data Fusion of Combat ID Onto Track Data	**F**
			• Connectivity To Allow Combat ID Data Accessibility by Crews in Flight	**A,B,&D**

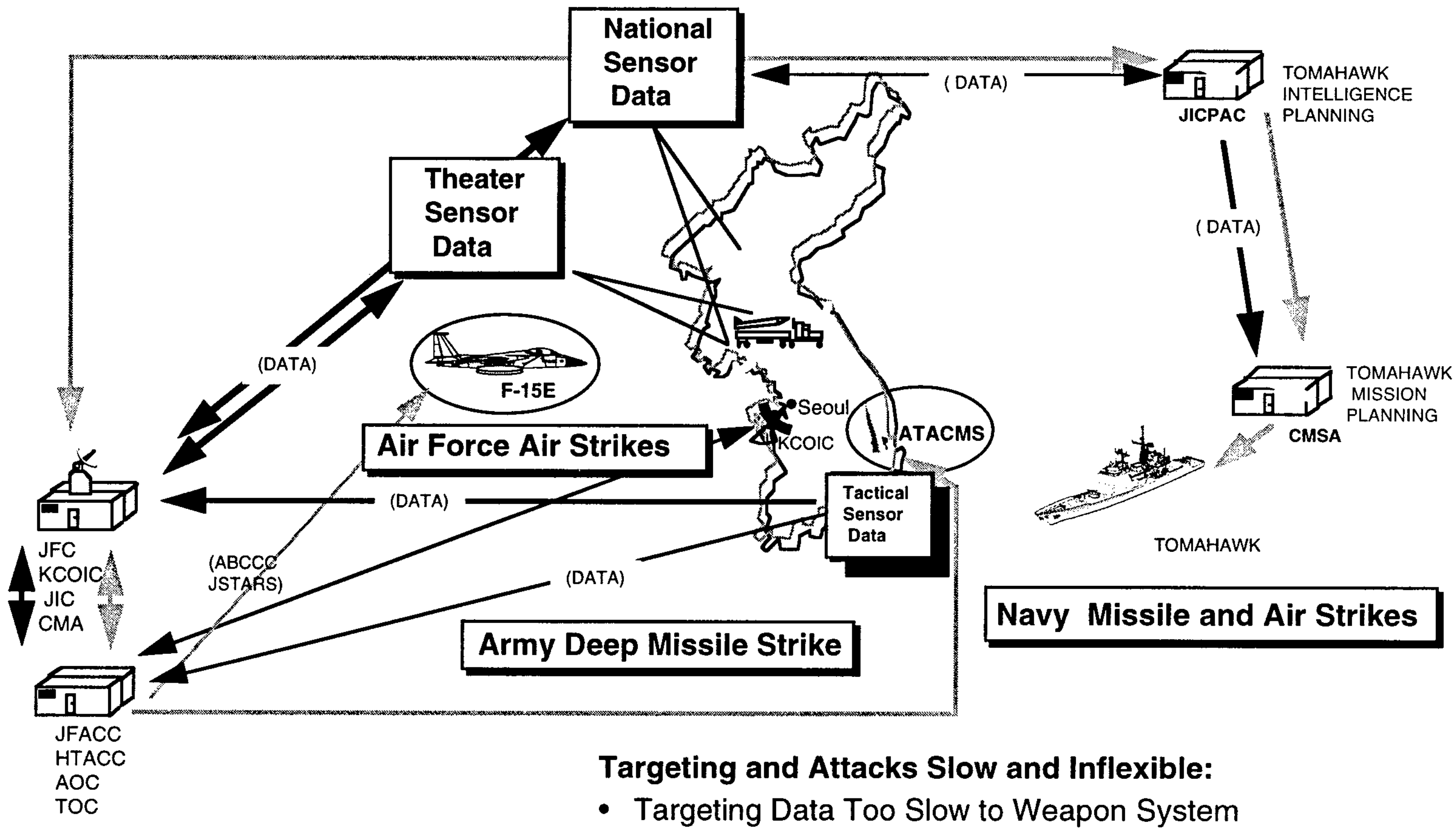
Operations–Technology Crosswalk Counterair Operations *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Situational Awareness Does Not Permit Rapid Decision-Making	• Information Transmission Is UHF Dependent	• Convey Information Needed Via Data Link	• Sensor Grid, Processing, and Links/ Grids Capable of Providing Information in Suitable Formats in a Dynamic Environment	**A,D,F,&H**
	• Absence of Data Link Standard and Cross-Transliteration	• Ability To Communicate Freely Between All Elements of Counter Force	• Development of Common, Distributed, and Composite Air-Ground-Naval Track Database	**A,B,D,F,&H**

Dynamic, Deep Targets



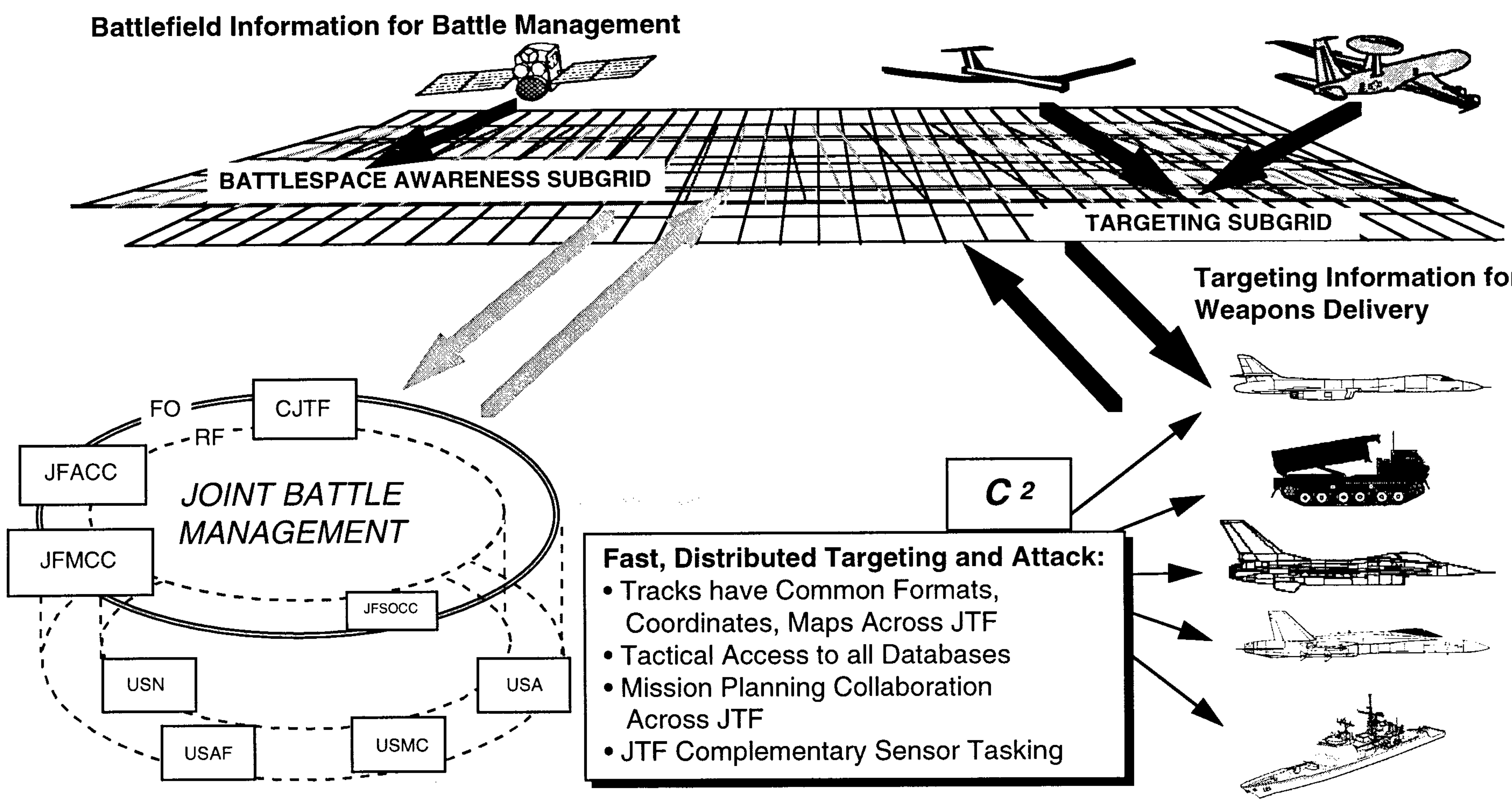
Dynamic, Deep Targets
Current Operations and STS Limitations



Targeting and Attacks Slow and Inflexible:

- Targeting Data Too Slow to Weapon System
- Stovepipe Targeting by Services
- Accuracy Affected by Different Geo, Timing, and Charting Standards
- Sensor-to-Shooter Management Too Linear

Dynamic, Deep Targets
Revised Operations and C4I Technology Challenges



Operations–Technology Crosswalk
Dynamic, Deep Targets

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Slow	• Time Delay Caused by Man-in-the-Loop Processing, Correlation, and Fusion Enroute to Shooter	• Automated and Semi-Automated Processing, Exploitation, Fusion, and Dissemination	• Automated Sensor Tasking/Nomination (Dynamically Updated) by Changing Battle Management Objectives	**A,C,G,&K**
			• Automated Target Recognition and Nomination for Priority Dissemination	**A,D,C,&G**
			• Automation Loading of Priority Target Data Into Weapon/Platform	**A,F,&J**

Operations–Technology Crosswalk Dynamic, Deep Targets *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Slow	• Time Delay Caused by Man-in-the-Loop Sanitization of Targeting Data	• Ability to Set Declassification/Sanitization Rules, Then Have Rule-Based Logic Software/ Firmware Auto-Sanitize Targeting Data Stream in Real-Time	• Automated Sanitization of Highly Classified Targeting Data in Real-Time	**A&J**
			• Automated Modification of Classified Formats to Different Formats at Equal and/or Lower Classifications	**A&J**
			• Automated Translation Form One Language to English and Simultaneously Declassify Data Stream	**A&J**

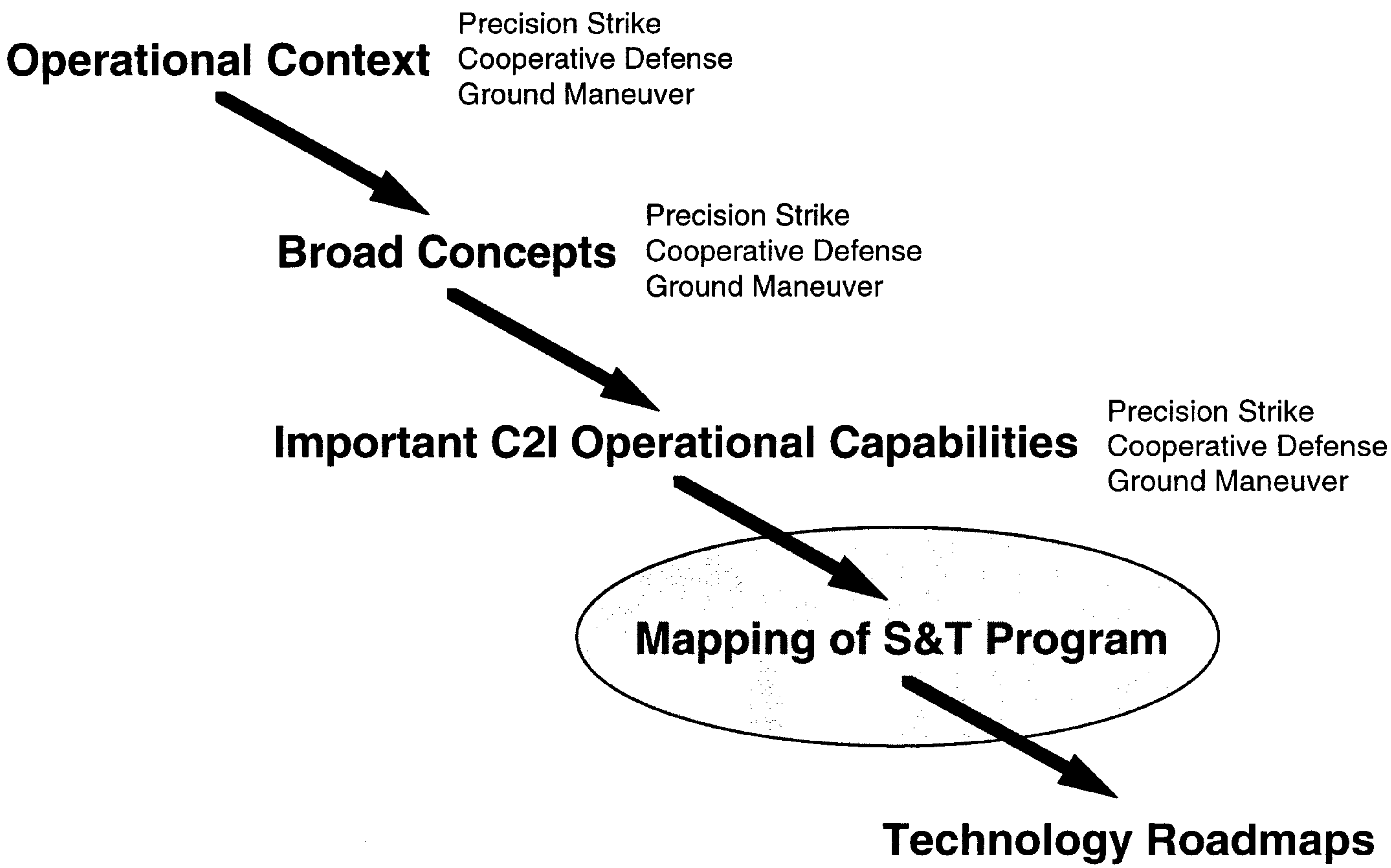
Operations–Technology Crosswalk Dynamic, Deep Targets *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• STS Timeline Too Slow	• Time Delay Caused by Broadcast/Transmission Delays	• Ability to Allow Head-of-the-Queue Privileges for Selected Targeting Data	• Automated Tagging of Targeting Data With Both Perishability and Broadcast Priority Codes	**A&D**
			• Provide Sufficient Bandwidth and Broadcast Management Schema To Ensure No Delays of Targeting Data in Broadcast Cues	**A,C,&D**

Operations–Technology Crosswalk
Dynamic, Deep Targets *(Continued)*

Current Limitations	Causes	Detailed Critical Functional Capabilities	Technology Challenges	
• Lack of Common Targeting Interoperability	• Different Data Handling Systems/Formats	• Ability for Data To Flow Between Sensors, Through C4I Systems, and Into Weapons Platforms and Weapons Systems	• Definition of Family of Interoperable Formats That Allow Connectivity Across National, Theater, Tactical and Allied C4I, Sensor, and Weapons Platforms	**D&J**
			• Automated Transliteration, Multilevel Sanitization, and Format Transliteration Software/Firmware	**D&J**

Sensor-to-Shooter Working Group Approach



Mapping of S&T Program
Current Operational Demonstrations

	Reviewed	Applicable
ACTDs	22*	11
ARMY ATDs	27*	10
NAVY ATDs	19*	4
AIR FORCE ATDs	101*	27

* Totals Appear Low

	Technology / ACTD	Advanced Joint Planning	HAE UAV	MAE UAV	Precision Rapid Counter MRL	Precision Signals Intel Tgting	Synthetic Theater of War	BADD	Combat Identification	Joint Logistics	Mil Ops in Built-up Areas	Auto Imagery Processing
A	Wideband Communications and Interconnectivity	?					X	X				?
B	Real-Time, Cognition Aiding Displays	X	/	/	X		/	X	/	X	?	
C	Automated Planning/Decision Support Tools	X	/	/	X		/			/	?	
D	Data Interoperability/ Synchronization	/	/	/		/	/	/	/	X	?	?
E	Automated IPB Processes											X
F	Fusion—Sensor Fusion as Well as Information Fusion	/	/	/		/	/	/	/		?	
G	Automatic Target Recognition and Acquisition		/		/			/				X
H	Integrated Target Tracking					/						
J	Multilevel Security						/		/			
K	ISR Management and Integration	/	/	/	/			/			?	

Legend
? - possibly addressing some aspect
/ - addressing some aspect
X - focused on specific technology

	Technology / ATD	Army ATDs: Rotor Craft Pilot's Assoc	Army ATDs: Radar Deception and Jamming	Army ATDs: Survivable Adaptive Systems	Army ATDs: Combined Arms C2	Army ATDs: Battlefield Combat ID	Army ATDs: Digital Battlefield Comms	Army ATDs: Common Ground Station	Army ATDs: Hit Avoidance	Army ATDs: Hunter Sensor System	Army ATDs: Remote Sentry	Navy ATDs: Voice Data Integrations	Navy ATDs: Low Prob of Intercept	Navy ATDs: HF Surf Wave Radar	Navy ATDs: Sub HF Phased Array Radar	Air Force ATDs: Situation Awareness Insert	Air Force ATDs: Speakeasy MBMMR
A	Wideband Communications and Interconnectivity	/		X	/		X	/				/			?	/	/
B	Real-Time, Cognition Aiding Displays	/			/	/		X								/	
C	Automated Planning/Decision Support Tools				/	/		/	/							/	
D	Data Interoperability/ Synchronization	/		/			/										
E	Automated IPB Processes										/						
F	Fusion—Sensor Fusion as Well as Information Fusion		/	/	/		X	/	/						?	/	
G	Automatic Target Recognition and Acquisition																
H	Integrated Target Tracking									/							
J	Multilevel Security	/		/	/		/	/		/			/				
K	ISR Management and Integration	/	/	/	/			/						/		/	

Legend
? - possibly addressing some aspect
/ - addressing some aspect
X - focused on specific technology

	Technology / Air Force ATDs	Defensive Planning	Distributed Air Ops Center	Ops/Intel Integration	Ops/Intel Integration Phase II	JTF Network Control	Reach Back for the Warrior	Survivable ATM	Robust Arch for Adaptive Tracking	USTRANSCOM Planning Tools	Hypermedia Integration	Advanced Hypermedia Integration	Enhanced All Source Fusion for EW	Automated Concept Generation	Collaborative Decision Support Demo	Multiple Data Base Integration & Update
A	Wideband Communications and Interconnectivity					X	X	X				?				
B	Real-Time, Cognition Aiding Displays	X	?		X					?					?	
C	Automated Planning/Decision Support Tools	X	X	X	X					X			?	X	X	
D	Data Interoperability/ Synchronization		X	X	X	X	X	?			X	X				
E	Automated IPB Processes	?	/	/	/				?					X		X
F	Fusion—Sensor Fusion as Well as Information Fusion	/	?	?	?	?			?		X	X	X	?		/
G	Automatic Target Recognition and Acquisition															
H	Integrated Target Tracking	?							X							
J	Multilevel Security			X	X	X		X								
K	ISR Management and Integration	/	?	/	/				X		?	?	?	X	X	/

Legend
? - possibly addressing some aspect
/ - addressing some aspect
X - focused on specific technology

	Technology / Air Force ATDs	Speakeasy MBMMR	Sigint Correlation	Text Exploitation Prototype	Update Analysis	Active Systems Exploitation	Hostile Target Identification	JSTARS Cueing and Correlation Demo	BISTATIC Onboard RT Fusion Processing	Real Time Application of Intelligence	Real Time Cueing and Id	Target ID for Tactical Application
A	Wideband Communications and Interconnectivity	X										
B	Real-Time, Cognition Aiding Displays		?							X	?	
C	Automated Planning/Decision Support Tools			X			?			X	?	
D	Data Interoperability/ Synchronization				X							
E	Automated IPB Processes		?	?						?		
F	Fusion—Sensor Fusion as Well as Information Fusion		X			/	X	X	X	X		
G	Automatic Target Recognition and Acquisition		?			X	X	X	X		X	X
H	Integrated Target Tracking							X	X		X	
J	Multilevel Security	?										
K	ISR Management and Integration			X	X		?	X	X	/		X

Legend
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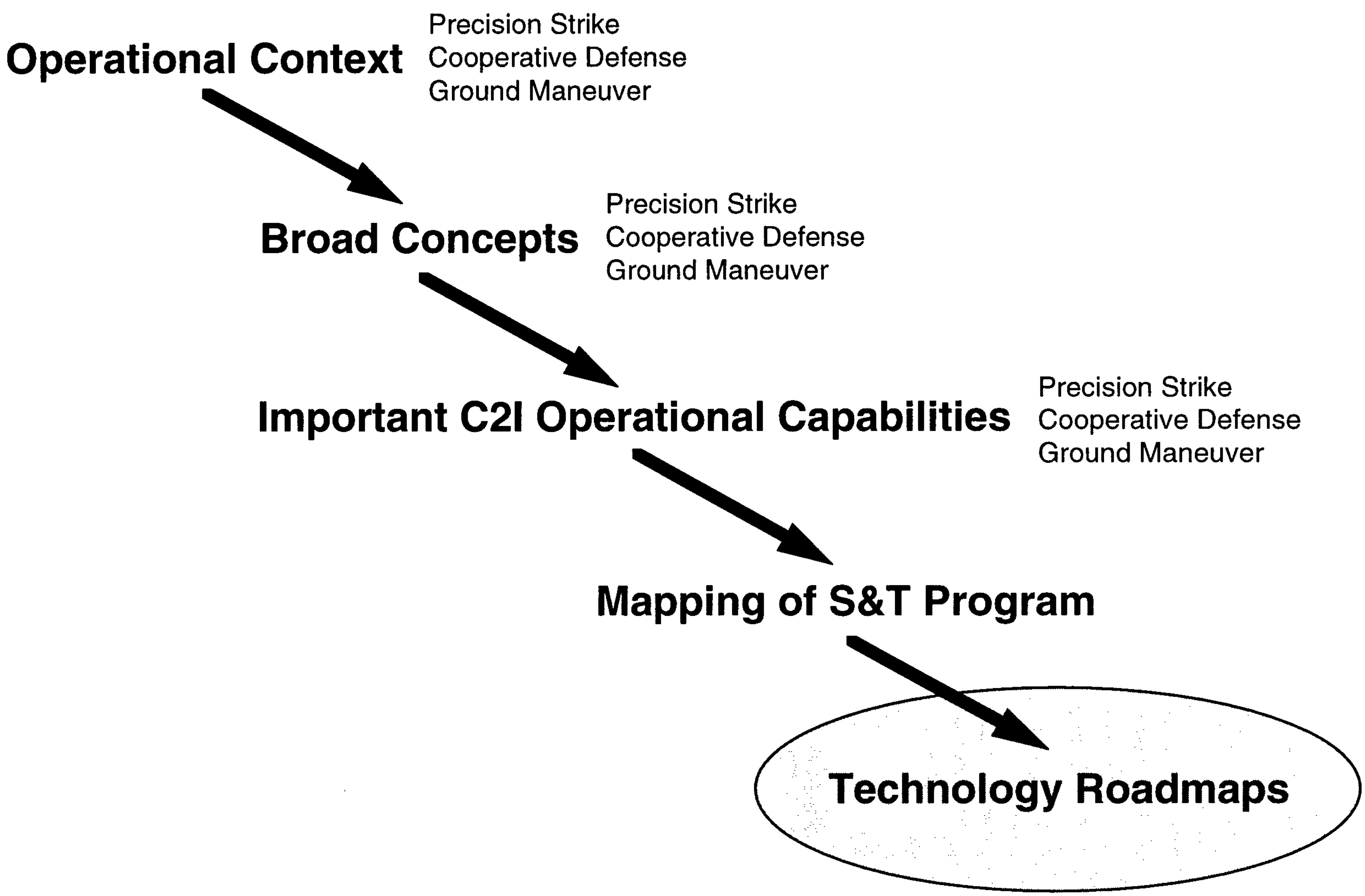
Sensor-to-Shooter Working Group Approach



Technology Package Demonstrations Recommended

	Technology R&D	ATD	ACTD
Wideband Comm and Interconnectivity			XX
Real-Time Cognition Aiding Displays	X	X	XX
Automated Planning and Decision Supt Tools		X	XX
Data Interoperability/Synchronization		X	
Automated IPB Processes			XX
Fusion	X	X	XX
Automated Target Recognition and Acquisition	X	X	X
Integrated Target Tracking		X	XX
Multilevel Security	X	X	XX
ISR Management and Integration		X	X

X Focused Technology Investments Recommended To Support Sensor-to-Shooter Operations

XX Operational Application Investments Recommended, Integrated With Other Appropriate Technologies

Technology Package Demonstrations Recommended

The 10 areas identified in the preceding section were assessed to define key objectives and their potential for accomplishment in the near term versus the long term. This figure and the following four figures provide an overview of the technology demonstrations that the working group believes are necessary. Subsequently, these areas were assessed for their overall contribution to the military effectiveness of sensor-to-shooter operations and were ranked in order of priority.

Recommended STS Demonstrations

Technology	Description	Near-Term Objectives	Future Objectives
• Wideband Communication and Interconnectivity	• Interactive, Group Connectivity From Sensors to Shooters for Targeting and Situation Awareness Information	• Bandwidth and Connectivity for Precision Strike/Air Defense Operations • Bandwidth and Connectivity Enabling Mission Planning and Execution Collaboration	• Bandwidth and Connectivity Enabling Multimission Operations and Collaboration
• Real-Time Cognition Aiding Displays	• Video-Voice-Graphics Displays Providing 3-D, Red and Blue, Multiservice Multiechelon Remote Collaboration Capability	• AF-Army Integrated Precision Strike/Air Defense Common Air Picture • Mission Tailorable Displays • Situation Awareness R&D • Two-Site VTC Without Graphics Interaction	• All Service, All Mission Common Picture of Battlespace • Mission Tailorable Displays • Full Capability Group Interaction
• Auto Planning and Decision Support Tools	• Increased Strike Execution Effectiveness Through Dynamic Target List Updating and Real-Time Retasking	• NRT All Service Precision Strike Strategy To Task ITO Generation • NRT Mobile Target Position Updates and Strike Retasking	• RT All Service, All Mission Strategy To Task ITO Generation • RT Mobile Target Position Updates and Strike Retasking

Recommended STS Demonstrations *(Continued)*

Technology	Description	Near-Term Objectives	Future Objectives
• Data Interoperability and Synchronization	• Development of Common Formats, Protocols, and Reference Frames	• Interoperability of Air Defense Systems Data With Precision Strike Systems Data • PS Data Interoperability From Sensor to Shooter	• Multimission Data Interoperability • Multinational Systems Data Interoperability
• Auto IPB Processes	• Integrated, Multimission NRT Automated Display and Assessment of Natural and Threat Environment	• Shooter Oriented Displays for Precision Strike Missions • Integration of Target Infrastructure, Terrain, and Weather Information	• Shooter Oriented Displays for All Missions • Integrated Display and Representation of All Supporting Information
• Fusion	• Integration of All Source Sensor Data With Other Target Knowledge	• Correlation and Fusion of MTI and Imagery • Limited Spectrum Signature-Behavior Libraries/Templates	• Correlation and Fusion of MTI, Imagery, SIGINT, ISAR, Etc. • Full Signature-Behavior Library/Templates

Recommended STS Demonstrations *(Continued)*

Technology	Description	Near-Term Objectives	Future Objectives
• Automated Target Recognition and Acquisition	• Automated or Semi-Automated Classification of High Value Targets and Their Infrastructure	• Detection/Classification of Correlated MTI and Imagery Signatures in Medium Clutter • Cueing for Manual Decisions	• Detection/Class. of Correlated, Full Spectrum Signatures in High Clutter • Automated Decisions
• Integrated Target Tracking	• Continuous Tracking of Mobile Targets Over Multiple Target Operation Cycles Using Multiple Sensors	• Correlation of Time Interrupted (Hours) Tracks for Same Sensor • Common Composite Track Database for 2–3 Sensor Types	• Distributed, Synchronized Tracking • Common Composite Track Database for All Theater Sensors (Track ID and Geolocation)

Recommended STS Demonstrations *(Continued)*

Technology	Description	Near-Term Objectives	Future Objectives
• Multilevel Security	• Integration and Exploitation of All Source Sensor Data With Other Target Knowledge	• Automated Sanitization of Highly Classified Formatted Targeting Data in Real Time • Automated Sanitization of Classified Imagery Chips to Secondary Imagery in Near Real-Time	• Automated Sanitization of Formatted and Unformatted English and Non-English Targeting Data in Real Time • Automated Sanitization of Classified Imagery With and Without Annotations (Including Metadata That Allows Mensuration) in Real-Time
• ISR Management and Integration	• Automated, Integrated Tasking and Management of Tactical and National ISR Assets	• Coordinated Tasking Of Tactical MTI and IMINT Assets • Planning for 24-Hour Cycle of Tasking • Multiorbit Sensor and Route Planning • NRT Retasking of Sensor Plans	• Coordinated Tasking of MTI, SIGINT,IMINT, and Other Assets • Planning for 72-Hour Cycle of Tasking • Integrated Planning and Tasking of Tactical and National Assets • RT Retasking and Optimization of Sensor/ Route Plans

Sensor-to-Shooter Top-Priority Technologies

- First, the Technical Framework Must Provide Rapid, Universal Access to Targeting Data Between Sensors and Shooters
- Then, the Top Priority Technologies Focus on:
  - Shooter-Focused Automated Planning/Decision Support Tools
    - » Real-Time Target-Weapon Pairing
    - » Real-Time Sensor-Target Pairing
  - Shooter-Focused Rapid Knowledge Enhancement
    - » Automated Target Recognition
    - » Integrated Fusion and Target Tracking
- Other Key Technologies of Importance Are:
  - Automated IPB Processes
  - Real-Time, Cognition Aiding Displays
  - Data Interoperability/Synchronization
  - Wideband Communications and Interconnectivity
  - Multilevel Security
  - Dynamic ISR Resource Management

Sensor-to-Shooter Top-Priority Technologies

The top priorities needed to enable the proposed sensor-to-shooter operations are as follows:

1. A technical system framework must be put in place that will provide rapid universal access to targeting data (this means target location and identification, situation awareness in the target area, and clearance to shoot). Although implementation of the Grid can clearly satisfy this priority, it is not the only solution. The requirement is for complete sensor-to-shooter connectivity and the ability to exchange data, whether these capabilities are achieved through technological development, procedural change, or some combination of the two. When this framework is ensured, the sensor-to-shooter operations concept can capitalize on the benefits of technology advances.

2. Although progress in all of the identified technologies is desirable, the Sensor-to-Shooter Working Group recognized that all 10 technologies could not be simultaneously pursued because it would not be affordable. Consequently, the working group prioritized the technologies required for achieving the critical operational capabilities, as follows:

   - Automated planning/decision support tools, such as real-time target-weapon pairing and target-sensor pairing.

   - Rapid battlespace knowledge enhancement—a combination of automated (or aided) target recognition combined with fusion and integrated target tracking technologies. Although these areas are distinct, they were combined into a single thrust area because their integrated product is the desired result. Integrating decision and tracking technologies may prove useful in addressing this area.

In both cases, the working group noted that very similar technologies exist for battle management applications. Therefore, a shooter focus must be retained with these priorities to ensure that the appropriate timeliness and responsiveness are achieved. Moreover, these capabilities must not be traded off for additional depth or breadth that may be valuable for battle managers, but are not the top priority for the shooter.

Expected Operational Impact** of Key Technologies

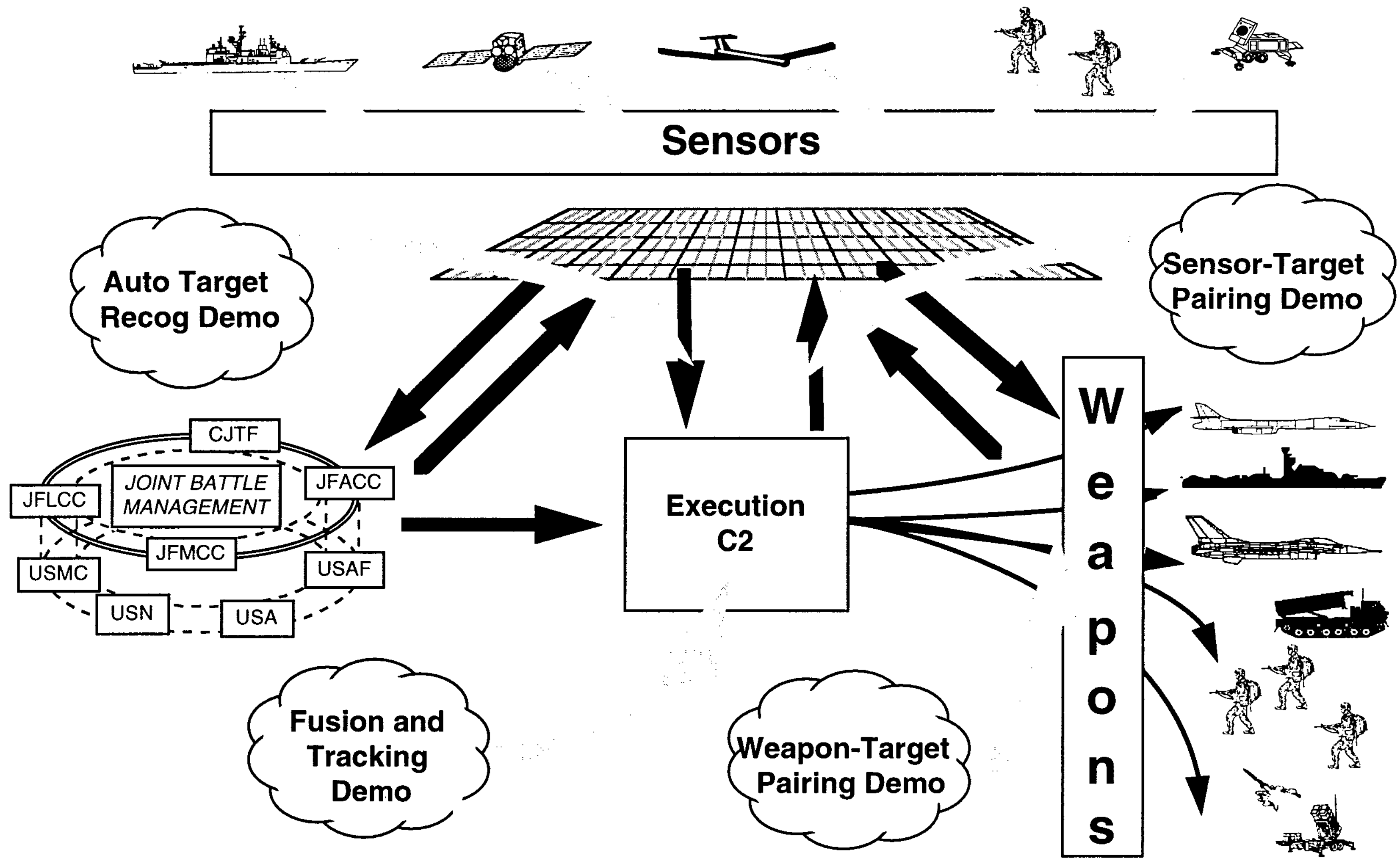
- Automated Weapon-to-Target Pairing
  - — Dynamic Targeting Times in Minutes (Versus Tens of Minutes to Hours)
  - — Enabling Weapon Launches in Under 5 Minutes
  - — Resulting in Reasonable Effectiveness (30–50 Percent) Against Time-Critical Targets (Versus Current 0 Percent)
- Automated Sensor-to-Target Pairing
  - — Dynamic Tasking Times in Minutes (Versus Hours)
  - — Enabling Near Real-Time Info for BDA and Shoot-Look-Shoot CONOPS
  - — Resulting in Substantial Increase (20–30 Percent) in Sortie Effectiveness
- Automated Target Recognition
  - — Near Real-Time Target ID and False Target Rejection Through Entire Spectrum of Target Environments
  - — Enabling BDA and/or Dynamic Targeting
  - — Resulting in Increased Sortie Effectiveness
- Integrated Fusion and Target Tracking
  - — Birth to Death Target Identification and Tracking
  - — Expanding Target Windows of Vulnerability by 200–300 Percent
  - — Resulting in Substantial Effectiveness Versus Time-Critical Targets (30–60 Percent)

** Based on Related Studies and Analyses

Expected Operational Impact of Key Technology Demonstrations

In operational terms, this is the expected impact of investing in the four technology demonstration areas. The format for each of the four areas is the same: first define the expected performance improvement produced through the technology demonstration, then identify the functional capability improvement enabled by the performance improvement, finally anticipate the increase in operational effectiveness resulting from the enhanced functional capabilities. Although specific analyses were not performed under the auspices of the ABIS study to develop these quantitative impacts, they do reflect an overall aggregation of the results of dozens of current detailed studies with which the Sensor-to-Shooter Working Group members are familiar. It is recommended that specific results for these technology areas be investigated through detailed studies when the overall architecture has been defined.

Key Opportunities for Near-Term Demonstrations



Key Sensor-to-Shooter Technology Demonstrations

- Automated Weapon-to-Target Pairing
- Automated Sensor-to-Target Pairing
- Automated Target Recognition
- Integrated Fusion and Target Tracking

Key Sensor-to-Shooter Technology Demonstrations

The four key technology demonstrations form key cross-service and cross-mission themes of technologies needed to resolve operational limitations (discussed previously in this section and expanded with specifics in the sensor-to-shooter appendix). As depicted in the figure, these demonstrations will enhance the shooter's effectiveness by giving the execution controller the tools and capabilities needed to enable time critical, shooter focused decisions and to execute these decisions in a joint environment.

These demonstrations take several forms. Some will be new demonstrations proposed for consideration along with other proposed FY97 ACTDs. Others will leverage off existing proposed demonstrations with endorsements and, in selected instances, expansion of scope to include both multiple services and expanded mission areas.

The key characteristics of the proposed demonstrations are that they allow tactical warfighters to address targets in parallel, and employ dynamic and fast-breaking tactical situations that will be typical of lesser regional conflicts, major regional conflicts, and contingency operations of the future.

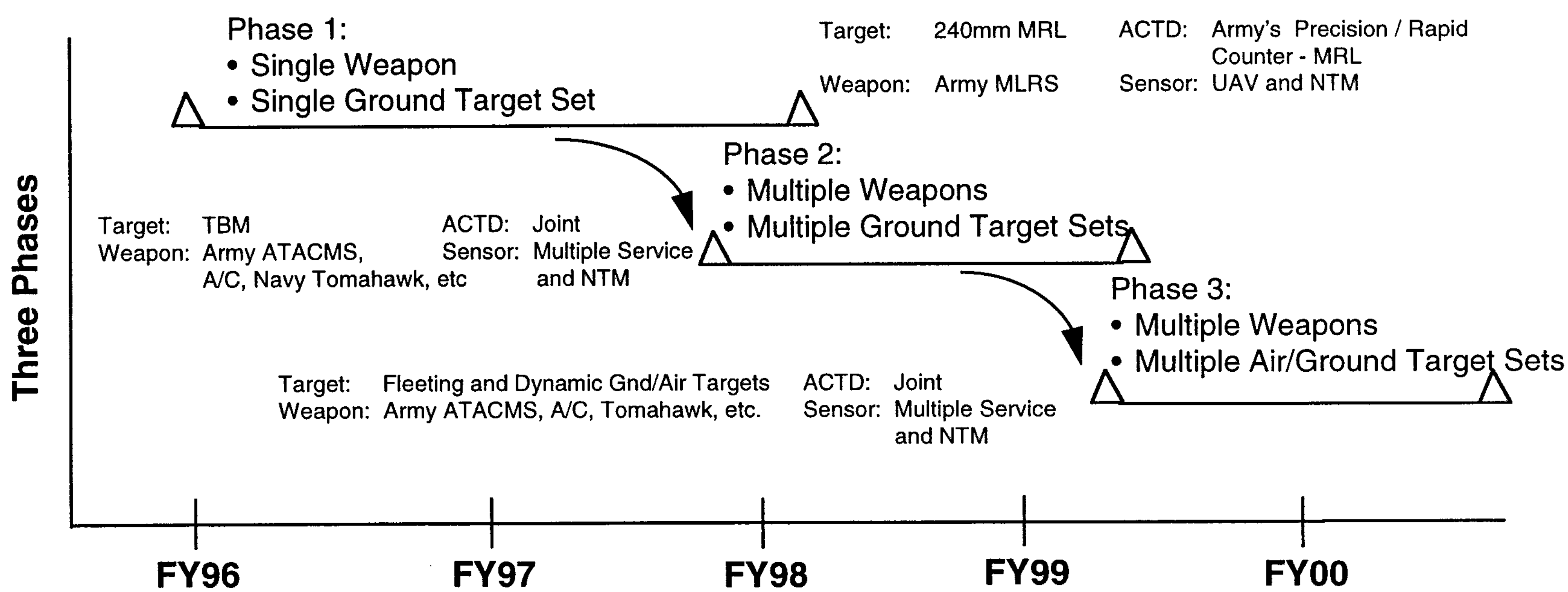
In the proposed demonstrations, sensors will continuously input new information into battlespace awareness databases that both executing elements (shooters and controllers) and battle managers will be able to tap.

The following figures expand each of these four areas into a technology roadmap providing a candidate initial plan of action (defining each phase with target class, weapons systems, and key junctions along the critical path). Note that these roadmaps are certainly not unique—any of several approaches could have been taken to achieve the same ends. However, to fulfill the original intent of the ABIS study, at least one approach to achieve the desired ends is presented for each case to illustrate and clarify the intention of the effort.

Automated Weapon-to-Target Pairing Technology Demonstration Roadmap

Objective: Against a Highly Mobile Target Set, Demonstrate Automated Pairing With Weapons Systems Optimized To Destroy Ground and Air Targets

Challenges:
- Resource Allocation/Optimization
- Collaborative/Distributive Planning



Automated Weapon-to-Target Pairing Technology Demonstration Roadmap

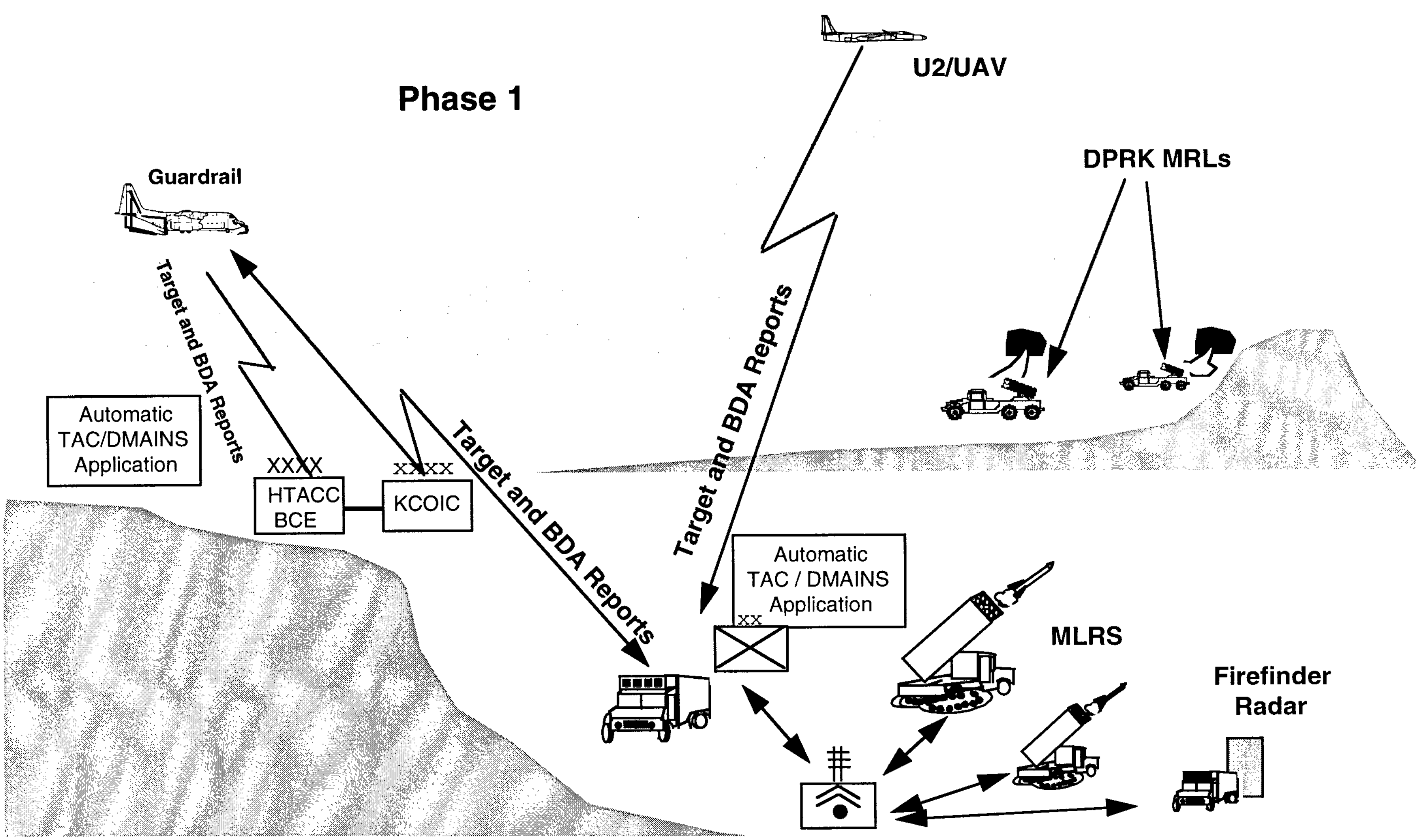
The first recommended demonstration is Weapon-to-Target Pairing. This capability will enable the execution controller to quickly select and allocate joint force weapons that are available, can reach the target in both range and in timeliness, and have adequate lethality to achieve the commander's intent. Because the execution controller must execute several sensor-to-shooter missions essentially simultaneously, the capability to execute against multiple target sets is necessary.

It is recommended that the demonstration have three phases:

- Phase 1—Single weapon versus a single ground target set
- Phase 2—Multiple weapons versus multiple ground target sets
- Phase 3—Multiple weapons versus multiple ground and air target sets.

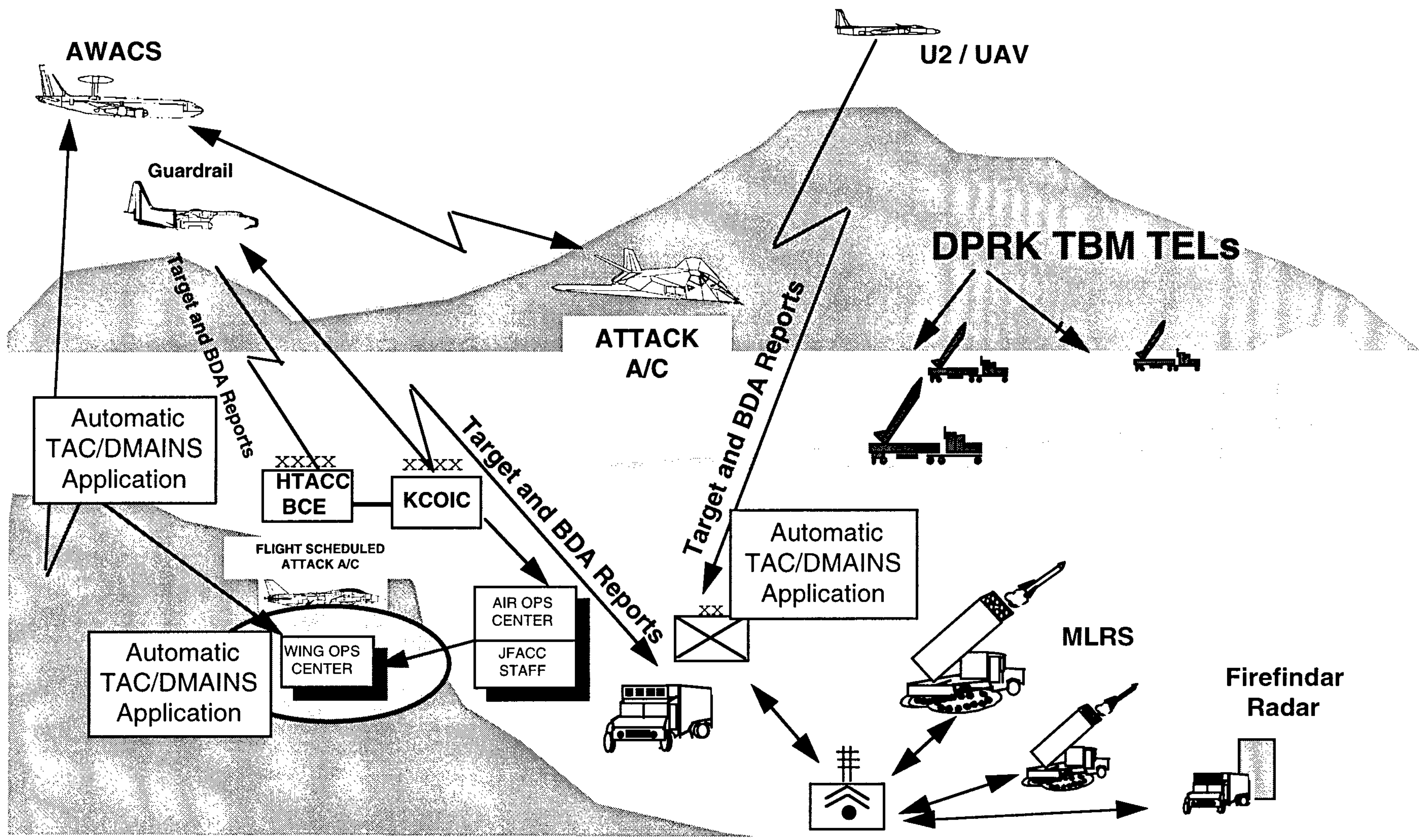
The first phase is essentially the same demonstration capability planned by the Army's Precision–Rapid Counter MRL ACTD against 240 mm multiple rocket launchers. Therefore, the primary purpose of this recommendation is to initiate early planning for logical extensions of the ACTD into joint force capabilities against multiple arrays of ground targets, followed by an extension enabling an integrated force versus both ground and air targets.

Army's Precision/Rapid Counter—MRL ACTD

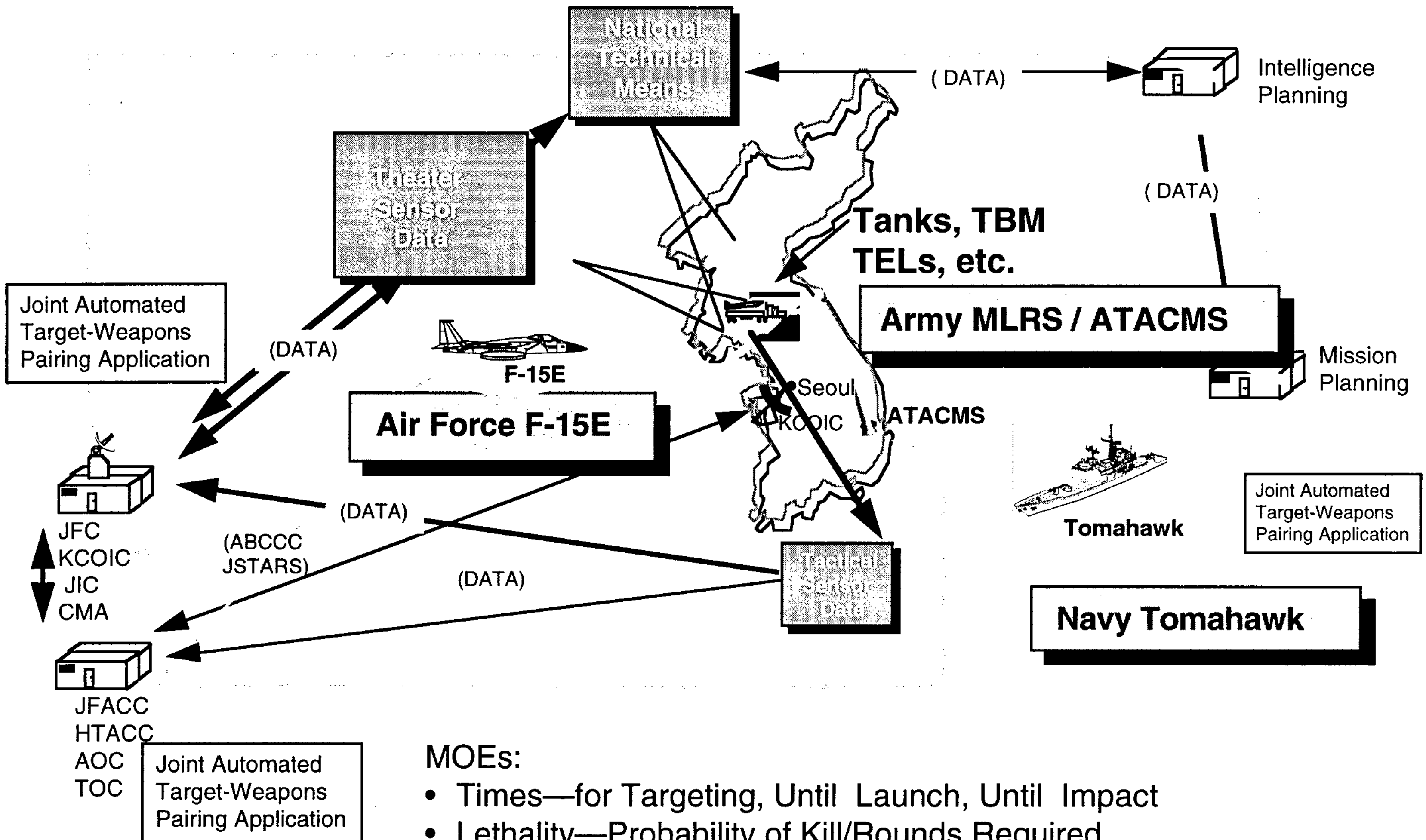


Proposed Joint Precision/Rapid Counter—TBM TEL ACTD

Phase 2



Proposed Joint Automated Weapon-to-Target Pairing Technology Demonstration

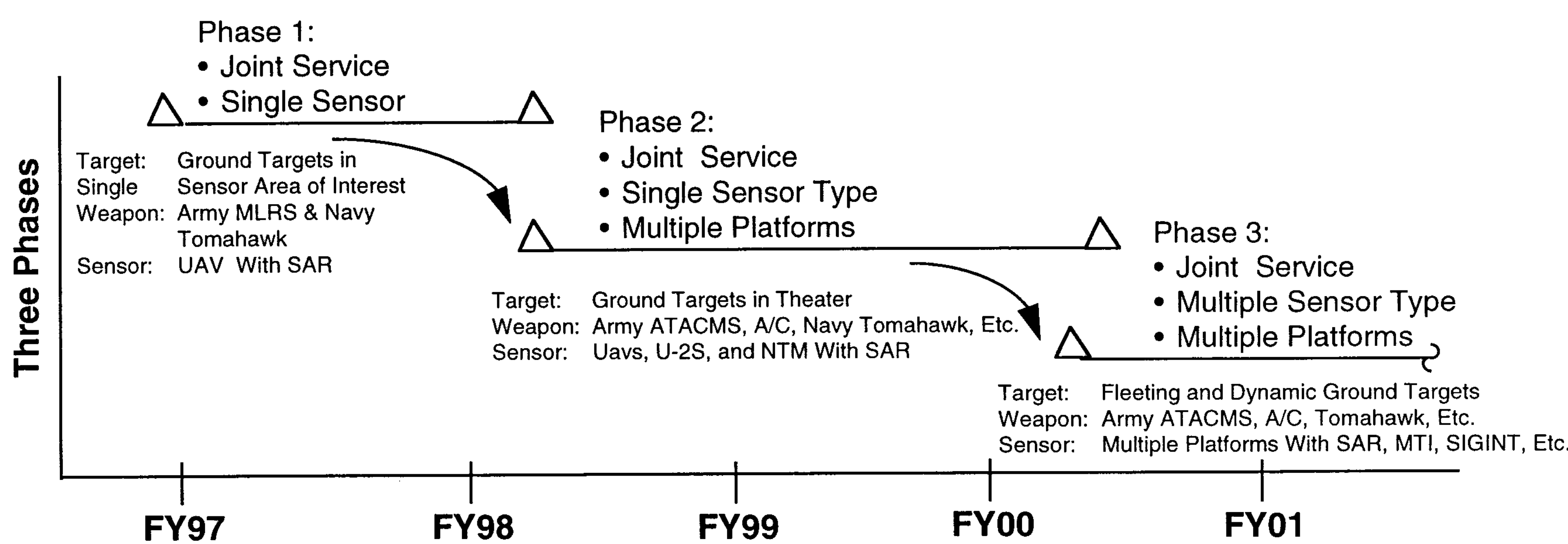


MOEs:
- Times—for Targeting, Until Launch, Until Impact
- Lethality—Probability of Kill/Rounds Required

Automated Sensor-to-Target Pairing Technology Demonstration Roadmap

Overall Objective: Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management

Challenges:
- Decision and Estimation Theory
- Constrained Resource Allocation



Automated Sensor-to-Target Pairing Technology Demonstration Roadmap

The second demonstration, while similar to the first, focuses on the problem of competition for sensors, that is, a Sensor-to-Target Pairing demonstration. This capability will enable the execution controller to select and allocate time slots of sensor capabilities and dedicate them, for a specific period of time, to individual missions in which shooters need current situation awareness. However, although the shooter support must be achieved in a timely manner, the impact of dynamic sensor retasking must be minimized so that the overall surveillance coverage of the target area is still achieved, thereby achieving the battle manager's information requirements.

This demonstration is inherently a joint demonstration because all key theater sensors are joint service sensors. Therefore, it is suggested that the demonstration have three phases:

- Phase 1—Single sensor (imagery) and single platform (UAV)
- Phase 2—Single sensor type (imagery) and multiple platforms (UAVs, U-2s, and overhead assets)
- Phase 3—Multiple sensor types (imagery, SIGINT, MTI, etc.) and multiple platforms

Phases 1 and 2 include elements similar to those of several proposed ACTDs. These are strongly endorsed. However, several dimensions need to be added to address all of the relevant issues, for example, sensor pointing only versus redirecting flight paths, multiple orbit, and multiple day optimization of target information.

Auto Sensor-Target Pairing Demonstration

- Overall Objective: Demonstrate Simultaneous Provision of Near Real-Time Sensor Information Directly to Shooters for Assigned Targets While Maintaining Coverage of Surveillance Areas for Battle Management
- **Phase 1:** Maximize Wide Area Surveillance Coverage of Battlefield Using <u>Single Sensor</u> Plus NTM, and Simultaneously Provide Imagery to Shooter Via <u>Dynamic Sensor Retasking</u>
- **Phase 2:** Achieve Specific Wide Area Surveillance Coverage Objectives (75–90 Percent) of Battlefield Using <u>Multiple Sensors of Same Type</u>, With <u>Dynamic Sensor and Flight Path Retasking</u>
- **Phase 3:** Achieve Specific Wide Area Surveillance and Target Coverage Objectives Despite Changing Target Behaviors, Using <u>Multiple Sensors of Multiple Types</u> With <u>Dynamic Sensor and Flight Path Retasking</u>

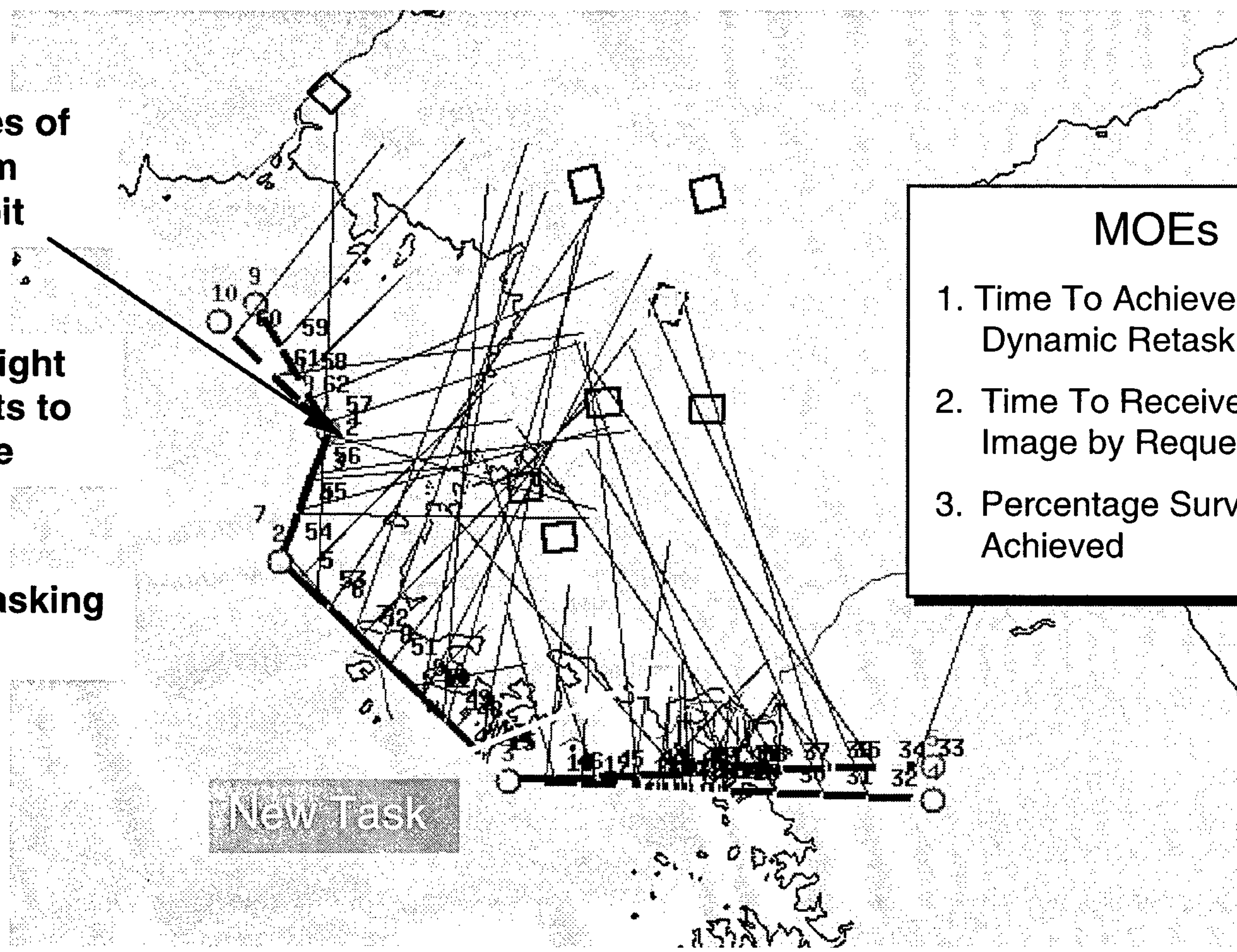
Auto Sensor-Target Pairing Demonstration
Multiorbit, Multisensor, Plus NTM Coverage With Dynamic Retasking

Phase 1

Multiple Passes of Single Platform Repeating Orbit

No Revised Flight Pathway Points to Achieve Recce

Dynamic Retasking for Shooter



MOEs

1. Time To Achieve Dynamic Retasking
2. Time To Receive Image by Requester
3. Percentage Surveillance Achieved

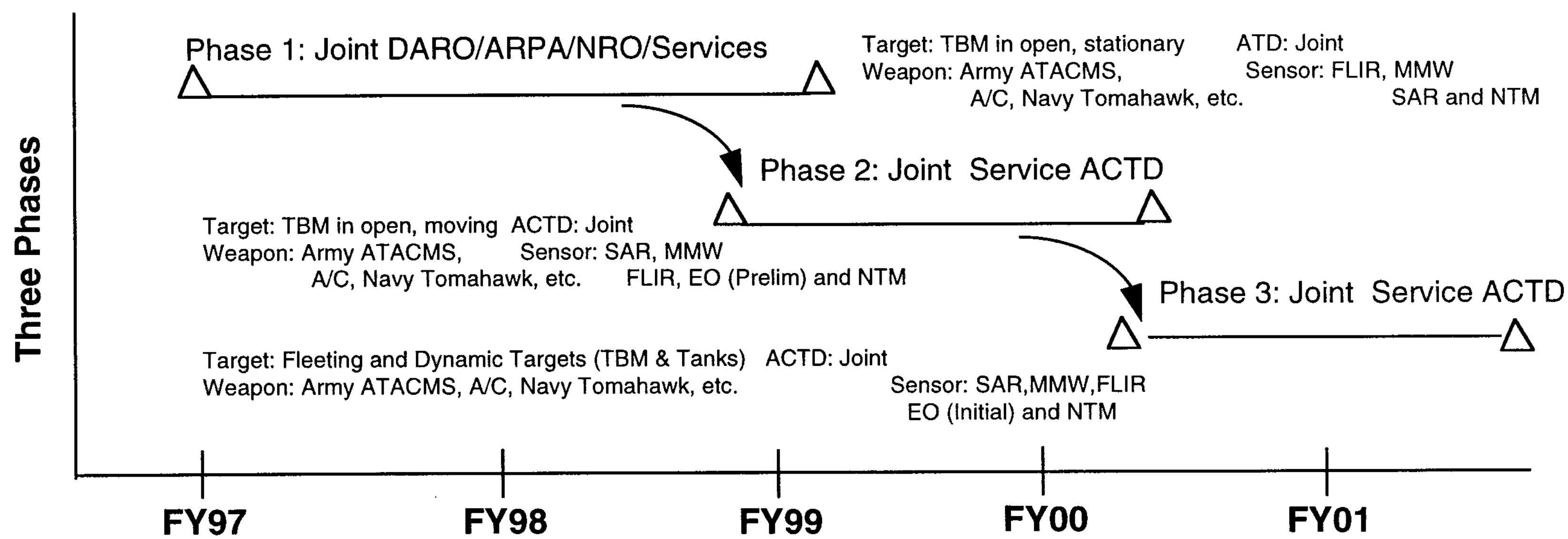
Auto Sensor–Target Pairing Demonstration
Progressive Incorporation and Integration of Sensors

Platform	No. of Orbits	No. of Vehicles	Sensor	Baseline Flight Path	Dynamic Flight Path Adjustment?	Baseline Daily Sensor Tasking	Dynamic Daily Sensor Tasking
Phase 1							
HAE	1	1	SAR	Ntl Boundaries	No	1,000 Images	100–200
NTM	1	1	SAR	Predictable	No		
Phase 2							
HAE	2	2	SAR	Ntl Boundaries	Yes	5,000 Images	300–500
NTM	1	1	SAR	Predictable	No		
U-2	1	4	SAR	Safe Ntl Boundaries	No		
MAE	2	3	EO/IR	Parked on Targets	Yes		
Phase 3							
HAE	2	2	SAR/MTI SIGINT	Ntl Boundaries	Yes	5,000 Images 1,000 MTI Scans 1,000 Intercepts	300–500 200 Scans
NTM	1	1	SAR/SIGINT	Predictable	No		
U-2	1	4	SAR/SIGINT	Safe Ntl Boundaries	No		
MAE	2	3	EO/IR	Parked on Targets	Yes		

Automated Target Recognition Demonstration Roadmap

Overall Objective: Against a High Value Target Set, Demonstrate Automated Target Recognition Linked With Weapons Systems

Challenges:
- Image Understanding
- Pattern Recognition
- Interactive Recognition
- Spatial Reasoning
- Template Matching
- Model-Based Recognition
- Temporal Reasoning
- Probabilistic Reasoning



Automated Target Recognition
Technology Demonstration Roadmap

The Automated Target Recognition demonstration focuses on the problem of rapid detection and recognition of target behaviors in multispectral signature regimes. Key MOEs are the time to detect and recognize relevant targets with high probabilities of success and low false alarm probabilities. An integrated measurements and target behavior characterization program is also a requirement for building a meaningful library of target signatures that can be used at any of several nodes in the end-to-end sensor-to-shooter "kill chain." The recommended demonstration program is focused primarily on the technology itself, not on the implementation architecture. Thus, this capability can be resident onboard sensors, at intelligence/fusion nodes, and at C2 nodes as well as with the execution controller. Depending on the theater architecture chosen for implementation, this overall capability may be distributed or centralized, parallel or serial, or any of several other alternatives. These implementation issues are not specifically recommended to be addressed in this demonstration. However, when the architecture has been selected, the technology implementation can be partitioned as appropriate.

It is suggested that the demonstration have three phases, based on complexity of target behaviors and the diversity of spectral signatures and sensors available:

- Phase 1—Temporarily stationary targets, imaging signatures
- Phase 2—Moving and stationary targets, imaging signatures
- Phase 3—Moving and stationary targets, imaging and other signatures.

ATR Capabilities Goals and Timelines

	1995	2000	2005
• Surface Targets			
– Large, Stationary, High Volume Target (Bridge)	Marginally Available	Marginally Available	Available
– Ship at Sea, or in Harbor	Marginally Available	Marginally Available	Available
– Unobscured Stationary Land Target, Low Clutter (Tank in Desert)	Technology Not Available	Marginally Available	Marginally Available
– Moving Targets in Traffic	Technology Not Available	Marginally Available	Marginally Available
– Stationary Tgt, Strong Clutter, Partial Masking, and CCD (SCUD in Trees)	Technology Not Available	Technology Not Available	Technology Not Available
• Wide Area Search Exploitation (HAE and ASARS)	Technology Not Available	Technology Not Available	Marginally Available
• Recognition (Prioritization)	Marginally Available	Marginally Available	Available
• Detection (Cueing)	Technology Not Available	Marginally Available	Marginally Available
• Classification	Technology Not Available	Technology Not Available	Marginally Available
• Identification	Technology Not Available	Technology Not Available	Technology Not Available

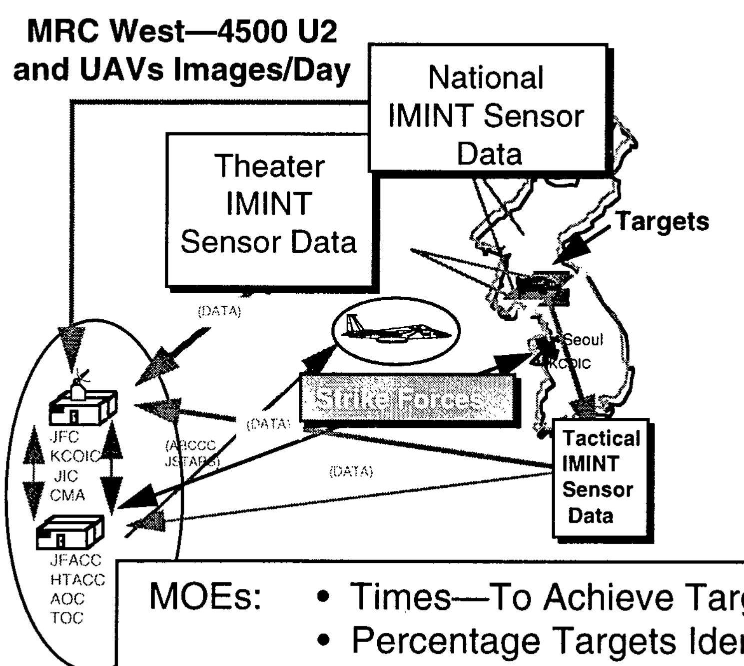
Source: ISR ATR Assessment — Technology Not Available — Marginally Available — Available

User Defines Focus, Developers Define Technology Maturity

Automated Target Recognition Imagery Problem

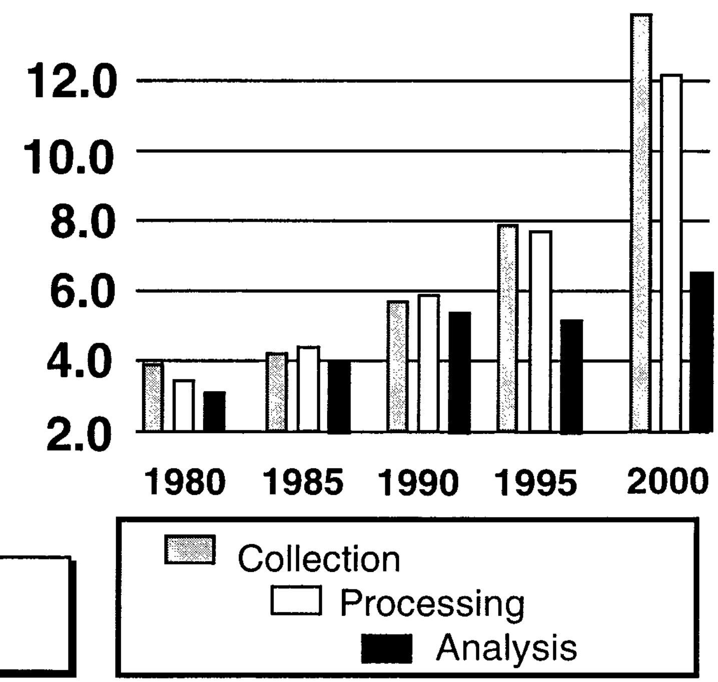
Year 2000
Imagery Load = 21,000 man-hrs/day
Capacity = 9,500 man-hrs/day

Sensor-Weapon Kill Chain: IMINT Choke Points

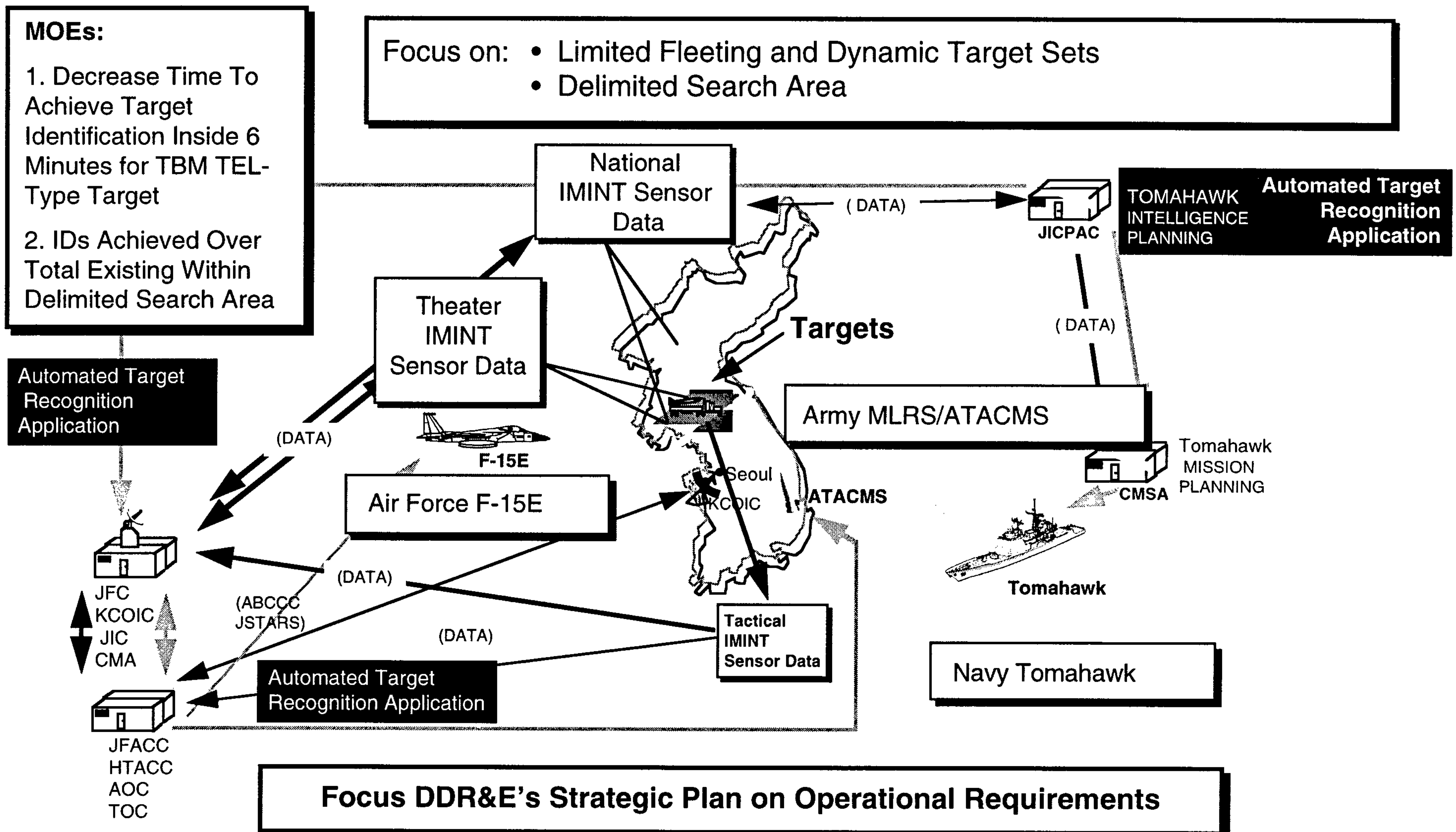


MOEs:
- Times—To Achieve Target ID
- Percentage Targets Identified

IMINT Balance Trends (Terapixel Capacity)



Automated Target Recognition ATDs Directly in Sensor-to-Weapon Kill Chain

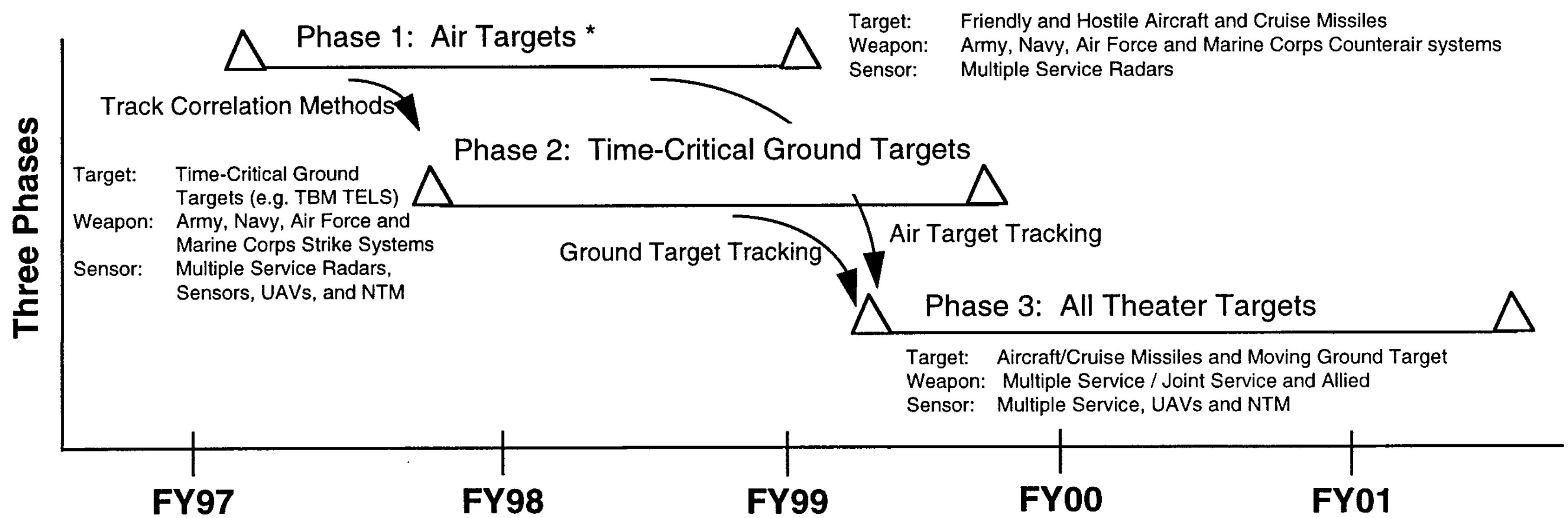


Integrated Fusion/Target Tracking Demonstration Roadmap

Objective: Demonstrate the Ability To Correlate and Fuse Diverse Sensor Information and Generate Birth-to-Death Target Tracks Spanning the Range of Target Behaviors (Emission, Moving, or Stationary)

Challenges:

- Model-Based Reasoning
- Multihypothesis Tracking
- Expert Systems
- Multispectral Decisions
- Bayesian Decision/Estimation
- Case-Based Reasoning
- Statistical Prediction/Correction
- Data Representation Structures



* ABIS STS Review Designated Navy CEC as Foundation for Phase 1

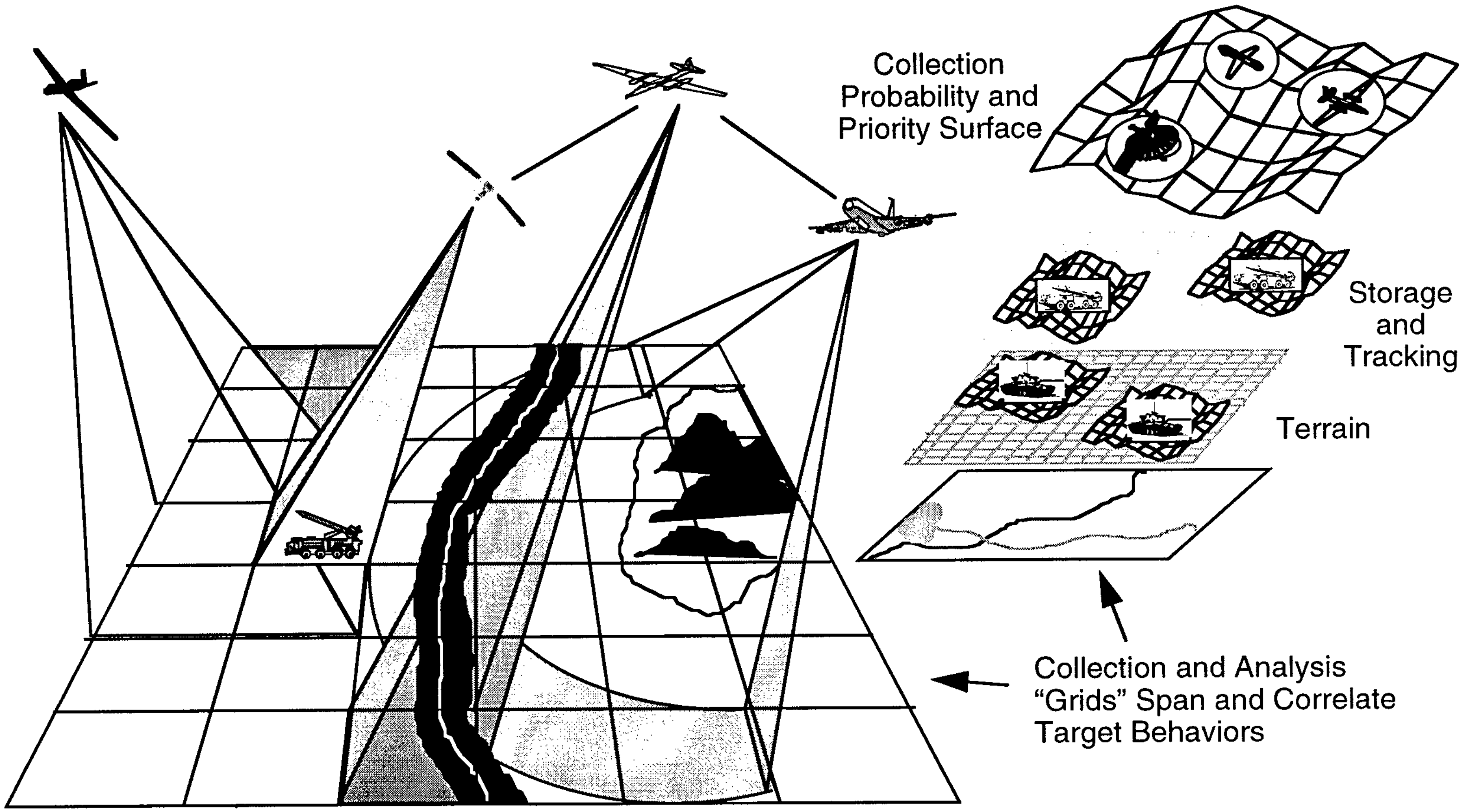
Integrated Fusion/Target Tracking Technology Demonstration Roadmap

The Integrated Fusion/Target Tracking demonstration focuses on the development of birth-to-death tracks of hostile targets. Accomplishment of this capability entails correlation of tracks from different sensors of the same type and different types of sensors tracking the entire spectrum of target behaviors. A key capability is the development and maintenance of a single, unique-track ID. The Navy is already developing these capabilities for air targets through the CEC program. Consequently, these track management methods should be extended to ground targets and eventually integrated into a complete air-ground display of the battlespace by mission areas.

As illustrated in the figure, it is suggested that the demonstration have three phases:

- Phase 1—Air targets
- Phase 2—Ground targets
- Phase 3—Integrated air–ground targets.

Integrated Sensor Fusion/Tracking Demonstration



MOEs:

- Accuracy—Probabilities of Correct Correlation and Miscorrelation Total Location Error
- Timeliness—Times to Correlate, Time To Fuse
- Percentage Time That Track Is Not Maintained

Integrated Fusion/Target Tracking Demonstration Suggested Phasing

Targets	Number	Sensors	Systems
Phase 1			
Air Targets	100s	Air Radar	AWACS/Patriot/Aegis
Phase 2			
SAM Sites	100s	IMINT	HAE/U-2
TELs and MRLs	100s	SIGINT/ELINT	HAE/U-2/RJ/NTM
		MTI	JSTARS/HAE
		DSP	
Phase 3			
Air Targets	100s	Same as Phase 1	
SAM Sites	100s	Same as Phase 2	
TELs and MRLs	100s	Same as Phase 2	
C2 HQ	Dozens	IMINT	HAE/U-2
		SIGINT	HAE/U-2/RJ-NTM
		MTI	JSTARS/HAE
Tanks/Trucks	1,000s	IMINT	HAE/U-2
		SIGINT	HAE/U-2/RJ
		MTI	JSTARS/HAE

Summary

- The Key Problem Is Competition for Sensors Within the Same Coverage Area Between Battle Managers and Shooters
- The Key Solution Is Enabling Distributed Command and Control Through:
  - — Automated Processing for Management of Time-Intensive Tasks
  - — Common Links To Share Optimization of Those Resources
- Four High-Payoff Technology Demos To Advance Toward the Solution Identified

Study Summary

The Sensor-to-Shooter Working Group assessed precision strike, coordinated defense, and ground maneuver operations, using six combat vignettes as a mechanism to focus on the needed operational capabilities. Through this process, the working group determined that the primary problem hampering sensor-to-shooter operations is competition for sensors between battle managers and shooters. Historically, the battle manager has won this competition, leaving the shooter with inadequate information to carry out the mission effectively.

The findings of the working group indicate that the most effective way to enhance the shooter's performance is to enable a distributed command and control approach, that is, implement an execution controller. This approach will provide the shooter with the needed targeting information in the most effective manner, without inundating him with irrelevant information as would other proposals to provide the shooter with real-time imagery.

Finally, the working group recommended four high-priority areas for technology demonstrations, each of which will make the execution controller in the sensor-to-C2-to-shooter loop more effective in executing the two key operational capabilities identified—coordination of multiple missions and execution of time-critical missions. Technology roadmaps were developed for each of these four areas. Development of these capabilities will enhance the overall ability of shooters to execute the intentions of the battle commander by enabling the prosecution of more targets, faster, and more effectively, thereby shortening any hostile engagements significantly. The eventual implementation and fielding of these capabilities will be the real enduring value of these technology demonstrations.

3. Glossary

ABCC	Airborne Command and Control
ABCCC	Airborne Command and Control Communications
ABIS	Advanced Battlespace Information System
ACTD	Advanced Concept Technology Demonstration
AD	Air Defense
AOC	Air Operations Center
AOR	Area of Responsibility
App	Application (usually refers to automated applications)
ARPA	Advanced Research Projects Agency
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
ATM	Asynchronous Transfer Mode
ATO	Air Tasking Order
ATR	Automated Target Recognition
AWACS	Airborne Warning and Control System
B-ISDN	Broadband Integrated Services Digital Network
BADD	Battlefield Awareness and Data Dissemination
BDA	Battle Damage Assessment
BM	Battle Management
bpp	Bits Per Pixel
C2	Command and Control
C2I	Command, Control, and Intelligence
C2W	Command and Control Warfare
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance
CDC	Combat Direction Center
CEC	Cooperative Engagement Concept
CEOI	Communications and Electronics Operating Instruction

CINC	Commander-in-Chief
CJTF	Commanders, Joint Task Force
CMA	Collection Management Authority
CMW	Compartmented Mode Workstation
COA	Course(s) of Action
COE	Common Operating Environment
CONOPS	Concept of Operations
CONUS	Continental United States
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off the Shelf
CP	Command Post
CVW	Collaborative Virtual Workspace
DBC	Digital Battlefield Communications
DBMS	Database Management System
DCE	Distributed Computing Environment
DDR&E	Director, Defense Research and Engineering
DISA	Defense Information Systems Agency
DMS	Defense Message System
DSP	Defense Support Program
DTAP	Defense Technology Program
DTO	Defense Technology Objective
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMI	Electromagnetic Interference
EO	Electro-Optical
ESM	Electronic Support Measures
FLIR	Forward Looking Infrared

FST	Fire Support Team
FTX	Field Training Exercise
GBS	Global Broadcast System
GOTS	Government Off the Shelf
HAE UAV	High-Altitude Endurance Unmanned Aerial Vehicle
HCI	Human-Computer Interface
HTACC	Hardened Tactical Air Command Center
IAW	In Accordance With
ID	Identity or Identification
IFF	Identification, Friend or Foe
IMINT	Imagery Intelligence
Infosec	Information Security
IP	Internet Protocol
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
ISAR	Inverse Synthetic Aperture Radar
ISDN	Integrated Services Digital Network
ISR	Intelligence, Surveillance, Reconnaissance
IT	Information Technology
ITO	Integrated Tasking Order
IW	Information Warfare
JBC	Joint Battle Center
JCPMS	Joint Communications Planning and Management System
JFACC	Joint Force Air Component Commander
JFC	Joint Forces Commander
JFLCC	Joint Force Land Component Commander
JFMCC	Joint Force Maritime Component Commander
JIC	Joint Intelligence Center
JIT	Just in Time

JPEG	Joint Photographic Experts Group (Standard)
JROC	Joint Requirements Overnight Council
JSTARS	Joint Surveillance and Target Acquisition Radar System
JTF	Joint Task Force
JWCA	Joint Warfighting Capability Assessment
KCOIC	Korean Command Operations/Intelligence Center
LRC	Lesser Regional Conflict
M&S	Modeling and Simulation
MASINT	Measurements and Signatures Intelligence
MC&G	Mapping, Cartography, and Geodesy
MILSATCOM	Military Satellite Communications
MLRS	Multiple Launch Rocket System
MLS	Multilevel Security
MMW	Millimeter Wave
MOE	Measure of Effectiveness
MRC	Major Regional Conflict
MRL	Multiple Rocket Launcher
MTI	Moving Target Indicator
NRT	Near Real-Time
NTM	National Technical Means
O&M	Operations and Maintenance
OIW	Operations/Intelligence Workstation
OPLAN	Operation Plan
OPSEC	Operations Security
OTAR	Over-the-Air Rekeying
OTH	Over the Horizon
PGM	Precision Guided Weapon
POM	Program Objective Memorandum
RDT&E	Research, Development, Test, and Engineering

REECE	Reconnaissance
RMA	Revolution in Military Affairs
ROE	Rules of Engagement
RT	Real-Time
S&T	Science and Technology
SA	Situational Awareness
SAR	Synthetic Aperture Radar
SAS	Survivable, Adaptable System
SATCOM	Satellite Communications
SIGINT	Signals Intelligence
SOF	Special Operations Force
SONET	Synchronous Optical Network
SSCN	Secure, Survivable Communications Network
STS	Sensor-to-Shooter
TAC	Tactical Air Controller
TAP	Technology Action Plan
TBM	Theater Ballistic Missile
TCP	Transaction Communications Protocol (used with IP)
TCT	Time-Critical Target
TEL	Transportable Erectable Launcher
TFCC	Task Force Command and Control
TLAM	Tomahawk Land Attack Missile
TOC	Tactical Operations Center
TOT	Time Over (or On) Target
UAV	Unmanned Aerial Vehicle
VCJCS	Vice Chairman Joint Chiefs of Staff
VTC	Video Teleconference

4. Working Group Membership

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CAPT Stephen M Soules	JS / J6I

Secretariat Representative

Dr. Klaus Dannenberg	Booz•Allen & Hamilton

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Sensor-to-Shooter Working Group Participants

To achieve the objectives of the ABIS Sensor-to-Shooter Working Group, a balance was needed between operators and technologists. The operators needed vision to consider new, “out of the box” ways of prosecuting combat objectives, while the technologists needed to be able to understand the real operational issues. The resulting working group membership included operators and technologists from all of the military services.